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NASA SP-7037(258)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 258)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in October 1990 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 536 reports, journal articles and other documents originally announced in October 1990 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cumulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

"PAGE MISSING FROM AVAILABLE VERSION"

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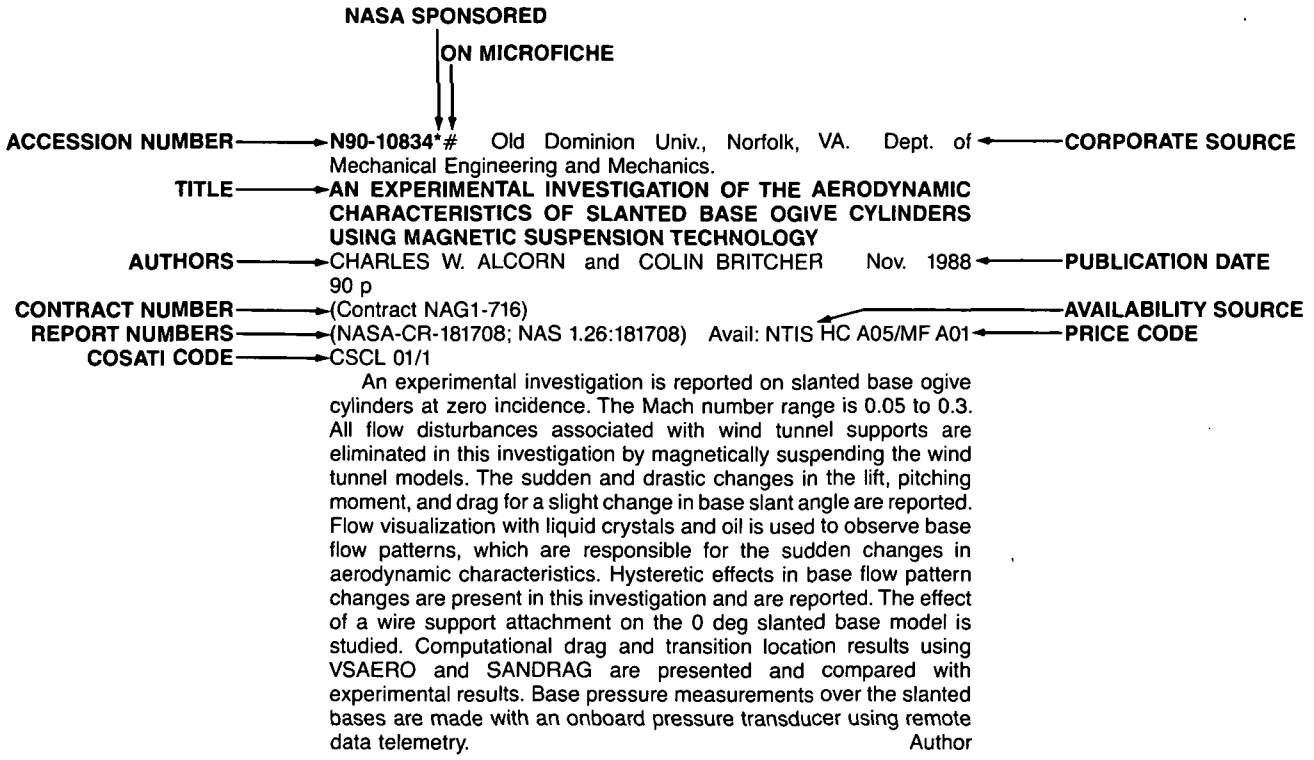

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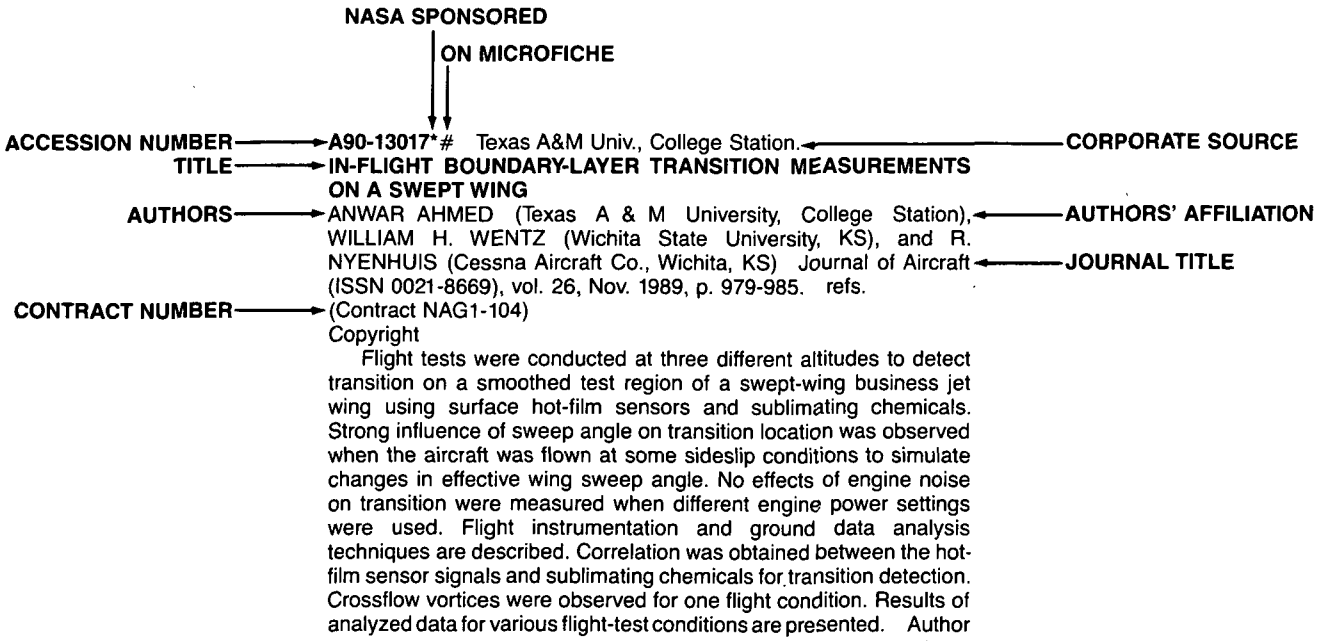

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 258)

NOVEMBER 1990

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AERONAUTICS (GENERAL)

A90-42652
ANNUAL GENERAL MEETING OF THE CANADIAN AERONAUTICS AND SPACE INSTITUTE, 36TH, OTTAWA, CANADA, MAY 15, 16, 1989, PROCEEDINGS
Ottawa, Canadian Aeronautics and Space Institute, 1989, 536 p. For individual items see A90-42653 to A90-42659, A90-42661, A90-42662, A90-42664 to A90-42675.

The present conference discusses ultrahigh bypass engine technology, the use of lunar dust as a propellant, the Canadian airspace system plan, the RJ-601 regional airliner, the velocity field of a reverse-flow combustor, flash-lamp planar imaging for high speed flow, advanced stress analysis techniques for gas turbine castings, erosion-resistant compressor airfoil coatings, mechanical processes in turbine blade thermal fatigue, blisked rotor fracture mechanics, and the Dash-8 series 400 regional airliner. Also discussed are future tactical cockpit systems, the integration of EW systems, two-dimensional experiments and simulations of turbine blade film-cooling, the BD-10J supersonic aircraft, a probabilistic approach to fleet management, marine environment airframe materials' fatigue testing, and ultralight aircraft design. O.C.

A90-42674#
PROBABILISTIC APPROACH TO FLEET MANAGEMENT
Y. THERIAULT and A. MARLEAU IN: Annual General Meeting of the Canadian Aeronautics and Space Institute, 36th, Ottawa, Canada, May 15, 16, 1989, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1989, p. 45-1 to 45-14. refs

Results are presented from a probabilistic crack growth analysis (PCGA) which ascertains the probability of failure at any stage in aircraft service life by accounting for the variability in fracture toughness, the statistical nature of service loads, the initial crack-size distribution, and the reliability of the nondestructive method employed for inspection. The illustrative case of PCGA presented pertains to the aircraft of a Canadian Air Force training squadron. A significant influence is exerted on failure probability by the variation of inspection intervals. PCGA should be used as an alternative to deterministic analysis only when deterministic results are deemed to be excessively conservative. O.C.

A90-42794#
IHPTET TECHNOLOGY MISSION PAYOFFS AT THE COMPONENT LEVEL - A LOOK AT PHASE II TECHNOLOGIES
LEE COONS (United Technologies Corp., Pratt and Whitney Group, West Palm Beach, FL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 7 p.
(AIAA PAPER 90-2404) Copyright

A critical first step in the development of an advanced aircraft technology is the establishment of the anticipated payoff of the technology at the component level. The technique used to establish technology payoffs is described here, including a discussion of selected missions, notional aircraft, and the optimum propulsion system cycles used in the generation of these payoffs. The overall system improvement that can be anticipated with the application of a propulsion system with IHPTET Phase II technologies is addressed. The contribution at the component level of the individual technologies toward this overall system improvement is highlighted. C.D.

A90-43826
BUILDING THE B-2
CRAIG SCHMITMAN and GRAHAM WARWICK Flight International (ISSN 0015-3710), vol. 139, July 10, 1990, p. 24-27.
Copyright

In order to try and save as much of the threatened B-2 development and production program as possible, the USAF is starting to reveal a good deal more of the aircraft's advanced technology than it has previously. The airframe is mainly of composite construction, with some parts required to withstand temperatures of more than 300 C. Composite materials are surface conditioned with special coatings, that are presumed to be radar absorbing. Process automation is a key feature of a large number of manufacturing processes that include the high-speed cutting of composite materials by ultraknife, with simultaneous ink-jet marking, automatic tape-laying for integrally stiffened and large contoured parts, and corona-discharge cleaning of composite substrates and ion-gas dusting of machined honeycomb cores. Revealing these advanced manufacturing technologies has served to underline the resources already committed to producing the B-2. R.E.P.

A90-45426
BOEING 737 FUSELAGE STRUCTURAL INTEGRITY PROGRAM
I. H. HOOVER (Continental Airlines, Inc., Houston, TX) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 9 p.
(SAE PAPER 892207) Copyright

Early Boeing 737s were manufactured using a cold structural adhesive bonding process to attach internal doublers to the fuselage skin and to supplement rivets at the skin lap splices. The doublers carry loads and perform a fail-safe tear-stopping function. Failures of the adhesive bond have been found in some of the cold bonded components jeopardizing the design integrity of the fuselage pressure vessel. This paper examines the problem, service experience, and modifications currently being made to restore structural integrity; and relates these modifications to the other required elements in the current solution to the 'Aging Aircraft Problem'. Author

A90-45428
DEALING WITH THE AGING FLEET
M. RICHARD JOHNSON and ULF G. GORANSON (Boeing Commercial Airplanes, Seattle, WA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 12 p.
(SAE PAPER 892209) Copyright

Economic and market conditions have resulted in the use of commercial jet airplanes beyond their original economic design life objectives. The average age of the world airline jet transport fleet has increased from 8 to 12 years since 1980. Standard Boeing practices to support continuing airplane structural integrity include inspection and overhaul recommendations contained in

maintenance manuals and service bulletins. As airplanes exceed their economic design life objective, the incidence of fatigue increases and corrosion may become more widespread. This presentation is focused on recent special activities to assess the condition of the aging airplane fleet and other joint Boeing, airline and airworthiness authority reviews of service bulletins, corrosion control programs, basic maintenance and supplemental structural inspection programs, and structural repair quality. These initiatives will provide timely preventive maintenance recommendations that will support continued safe operation of aging jet transports until their retirement from service. Author

N90-25073# Technion - Israel Inst. of Tech., Haifa. Dept. of Nuclear Engineering.
CONVEX MODELS OF MALFUNCTION DIAGNOSIS IN HIGH PERFORMANCE AIRCRAFT Final Report
YAKOV BEN-HAIM May 1989 77 p
(Contract AF-AFOSR-0209-88)
(AD-A218514) Avail: NTIS HC A05/MF A01 CSCL 01/3

This project is devoted to the study of diagnosis of additive malfunctions in linear dynamic systems. This class of failures is relevant to control-actuator failures in aircraft, as well as to other situations. In particular, we are interested in optimizing multi-hypothesis maximum-likelihood algorithms for malfunction diagnosis, since this concept is the most widely accepted basis for automatic malfunction diagnosis. The engineering system to be studied is a linearized aerodynamic model for small disturbances about a reference condition of steady rectilinear flight over a flat earth. The advantage of this system is its simple description of a wide range of aerodynamic situations, and the fact that control-actuator malfunctions can be modelled as additive failures. GRA

N90-25074# Naval Postgraduate School, Monterey, CA.
AIRCRAFT MODIFICATIONS COST ANALYSIS. VOLUME 1: OVERVIEW OF THE STUDY Final Report
DAN C. BOGER and SHU S. LIAO Feb. 1990 37 p
(AD-A220764; NPS-54-90-005) Avail: NTIS HC A03/MF A01 CSCL 01/3

As the budget for the development and production of new military aircraft tightens, modification of existing aircraft (MOD) has become increasingly important. This shift in emphasis has created a need for a high level parametric cost estimating method to estimate the cost of a MOD program early in the planning cycle. This report is the first volume of a series of reports documenting a multi-year project to support Naval Air Systems Command initiative to develop parametric cost estimating models for MOD programs. This volume provides an overview of the project, including a review of prior studies, the structure of data to be collected, and the forms used in data collection. Due to the proprietary nature of MOD program cost data, distribution of all future volumes of the report series except for the summary volume will be limited to selected Department of Defense agencies only. (jg) GRA

N90-25933*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
RESEARCH AT NASA'S NFAC WIND TUNNELS
H. KIPLING EDENBOROUGH Jun. 1990 9 p Presented at the 27th International Session of the Japan Society for Aeronautical and Space Sciences (JSASS) Aircraft Symposium, Fukuoka, Japan, 18-19 Oct. 1989
(NASA-TM-102827; A-90170; NAS 1.15:102827) Avail: NTIS HC A02/MF A01 CSCL 01/2

The National Full-Scale Aerodynamics Complex (NFAC) is a unique combination of wind tunnels that allow the testing of aerodynamic and dynamic models at full or large scale. It can even accommodate actual aircraft with their engines running. Maintaining full-scale Reynolds numbers and testing with surface irregularities, protuberances, and control surface gaps that either closely match the full-scale or indeed are those of the full-scale aircraft help produce test data that accurately predict what can be expected from future flight investigations. This complex has grown from the venerable 40- by 80-ft wind tunnel that has served for over 40 years helping researchers obtain data to better understand the aerodynamics of a wide range of aircraft from helicopters to the space shuttle. A recent modification to the tunnel expanded its maximum speed capabilities, added a new 80- by 120-ft test section and provided extensive acoustic treatment. The modification is certain to make the NFAC an even more useful facility for NASA's ongoing research activities. A brief background is presented on the original facility and the kind of testing that has been accomplished using it through the years. A summary of the modification project and the measured capabilities of the two test sections is followed by a review of recent testing activities and of research projected for the future. Author

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A90-42639
AN AIRFOIL THEORY OF BIFURCATING LAMINAR SEPARATION FROM THIN OBSTACLES
C. J. LEE and H. K. CHENG (Southern California, University, Los Angeles, CA) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 216, July 1990, p. 255-284. refs
(Contract N00014-82-K-0315)
Copyright

Global interaction of the boundary layer separating from an obstacle with resulting open/closed wakes is studied for a thin airfoil in a steady flow. Replacing the Kutta condition of the classical theory is the breakaway criterion of the laminar triple-deck interaction, which, together with the assumption of a uniform wake/eddy pressure, leads to a nonlinear equation system for the breakaway location and wake shape. Bifurcations of the steady-state solution are found among examples of symmetrical and asymmetrical flows, allowing open and closed wakes, as well as symmetry breaking in an otherwise symmetrical flow. Accordingly, the influence of thickness and incidence, as well as Reynolds number is critical in the vicinity of branch points and cutoff points where steady-state solutions can/must change branches/types. The study suggests a correspondence of this bifurcation feature with the lift hysteresis and other aerodynamic anomalies observed from wind-tunnel and numerical studies in subcritical and high-subcritical Re flows. Author

A90-42644* Arizona Univ., Tucson.
ON THE INSTABILITIES OF SUPERSONIC MIXING LAYERS - A HIGH-MACH-NUMBER ASYMPTOTIC THEORY
THOMAS F. BALSA (Arizona, University, Tucson) and M. E. GOLDSTEIN (NASA, Lewis Research Center, Cleveland, OH) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 216, July 1990, p. 585-611. refs
Copyright

The stability of a family of tanh mixing layers is studied at large Mach numbers using perturbation methods. It is found that the eigenfunction develops a multilayered structure, and the eigenvalue is obtained by solving a simplified version of the Rayleigh equation (with homogeneous boundary conditions) in one of these layers which lies in either of the external streams. This analysis leads to a simple hypersonic similarity law which explains how spatial and temporal phase speeds and growth rates scale with Mach number and temperature ratio. Comparisons are made with numerical results, and it is found that this similarity law provides a good qualitative guide for the behavior of the instability at high Mach numbers. In addition to this asymptotic theory, some fully numerical results are also presented (with no limitation on the Mach number) in order to explain the origin of the hypersonic

modes (through mode splitting) and to discuss the role of oblique modes over a very wide range of Mach number and temperature ratio. Author

A90-42646
FLOW OVER A LEADING EDGE WITH DISTRIBUTED ROUGHNESS
J. M. FLORYAN (Western Ontario, University, London, Canada) and U. DALLMANN (DLR, Institut fuer Theoretische Stroemungsmechanik, Goettingen, Federal Republic of Germany) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 216, July 1990, p. 629-656. Research supported by the Alexander von Humboldt-Stiftung and NSERC. refs
Copyright

An analysis of the flow over a leading edge with distributed roughness is presented. The analysis is focused on a small neighborhood of the stagnation line. The roughness is assumed to have a small amplitude and to be symmetric with respect to the stagnation line. Results show that roughness acts as a source of streamwise vorticity. The existence of a universal form of the flow field for long-wavelength roughness is demonstrated. It is shown that surface stresses tend to eliminate roughness if erosion or wall flexibility are admitted. The heat flow tends to concentrate at the tips of the roughness and this may lead to the generation of large thermal stresses along the surface of the leading edge. Author

A90-42658#
FINITE ELEMENT SIMULATION OF TURBULENT PROPELLER FLOWFIELDS
DOMINIQUE PELLETIER, ANDRE GARON (Ecole Polytechnique, Montreal, Canada), and JEAN-FRANCOIS HETU IN: Annual General Meeting of the Canadian Aeronautics and Space Institute, 36th, Ottawa, Canada, May 15, 16, 1989, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1989, p. 12-1 to 12-14. Research supported by Fond pour la Formation de Chercheurs et l'Aide a la Recherche, NSERC, and U.S. Navy. refs

A numerical procedure based on the Reynolds averaged, primitive variable Navier-Stokes equations is applied to the simulation of the axisymmetric flow near a propeller. The Navier-Stokes equations are solved by a penalty finite element method. Turbulent transport processes are modeled with a mixing length model. Comparisons with experimental measurements show good prediction of velocity and pressure. Author

A90-42659#
A COLOCATED FINITE VOLUME METHOD FOR SOLVING THE NAVIER-STOKES EQUATIONS FOR INCOMPRESSIBLE AND COMPRESSIBLE FLOWS IN TURBOMACHINERY - RESULTS AND APPLICATIONS
M. J. RAW, P. F. GALPIN, and B. R. HUTCHINSON (Advanced Scientific Computing, Ltd., Waterloo, Canada) IN: Annual General Meeting of the Canadian Aeronautics and Space Institute, 36th, Ottawa, Canada, May 15, 16, 1989, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1989, p. 13-1 to 13-13. refs

A robust, efficient and accurate CFD technology has been developed and implemented in computer codes for two-dimensional and three-dimensional viscous flow in turbomachinery. The method can model incompressible to supersonic flows, and can solve laminar or turbulent (k-epsilon model) flows. The paper briefly describes some of the details of the method and presents results for benchmark and application problems. Author

A90-42671#
DEVELOPMENT OF A ROBUST CALCULATION METHOD FOR TRANSONIC VISCOUS BLADE-TO-BLADE FLOWS
P. KOTIUGA, M. PEETERS, S. PRZYBYTKOWSKI (Pratt and Whitney Canada, Longueuil), J. LINDHOUT, and A. VELDMAN (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Annual General Meeting of the Canadian Aeronautics and Space Institute, 36th, Ottawa, Canada, May 15, 16, 1989, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1989, p. 36-1 to 36-18. refs

The development of a robust calculation method for transonic, viscous blade-to-blade flows has been initiated with the objective of improving the engineering design and performance of compressor blades. The work is based on the experience of strong viscous-inviscid interactions and the finite element analysis of transonic flow in axial turbomachines. This paper highlights the solution of the viscous shear layer equations and the status of coupling between the inviscid blade-to-blade and the viscous flow solvers. Author

A90-42697#
AN INVESTIGATION OF OBLIQUE SHOCK/BOUNDARY LAYER BLEED INTERACTION
A. HAMED (Cincinnati, University, OH) and T. LEHNIG AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 11 p. refs
(Contract F49620-88-C-0053)
(AIAA PAPER 90-1928) Copyright

The detailed flow field characteristics in an oblique shock wave laminar boundary layer interaction with bleed were investigated. The numerical solution for the flow field was obtained for the strong conservation-law form of the two-dimensional compressible Navier-Stokes equations using an implicit scheme. The computations modeled the flow in the interaction region and inside the bleed slot for an impinging oblique shock on a flat plate boundary layer. The computed results for the streamlines and the pressure and Mach number contours inside the bleed slot indicate that the flow is choked in the slot, with a recirculation zone near the upstream slot corner. The bleed results in the interaction zone demonstrate that flow separation is controlled. The interaction length is reduced and the downstream velocity profiles are more favorable than the separated flow results at the same shock strength without bleed. Author

A90-42708# Stanford Univ., CA.
TWO- AND THREE-DIMENSIONAL EFFECTS IN THE SUPERSONIC MIXING LAYER
N. T. CLEMENS and M. G. MUNGAL (Stanford University, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 14 p. Research supported by USAF and NASA. refs
(AIAA PAPER 90-1978) Copyright

Experimental results are presented which compare the structure of the turbulent, planar mixing layer for three different values of convective Mach number (0.28, 0.62 and 0.79). These values span the range of low to moderately high compressibility. Extensive planar Mie scattering visualizations are presented, where either mixed fluid or high-speed fluid is marked. The visualizations show that the supersonic mixing layer, when driven to low convective Mach number, behaves as an incompressible layer with characteristic two-dimensional, organized, Brown-Roshko structure. As convective Mach number increases, however, the mixing layer becomes highly three-dimensional, with little apparent two-dimensional, large-scale organization. This change in structure is due to a compressibility effect and is not a Reynolds number effect. Author

A90-42709*# Ohio State Univ., Columbus.
PRESSURE-BASED REAL-TIME MEASUREMENTS IN COMPRESSIBLE FREE SHEAR LAYERS
M. SAMIMY (Ohio State University, Columbus), G. S. ELLIOTT, and M. F. REEDER AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 19 p. refs
(Contract N00014-90-J-1730; NAG3-764)
(AIAA PAPER 90-1980) Copyright

A preliminary experimental study has been conducted to gain insight into the temporal and spatial contents of largescale structures in a convective Mach number = 0.51 high Reynolds number planar two-dimensional compressible free shear layer. Power spectra, coherence, and space-time correlations were obtained using single- and two-point pressure measurements. Both developing and fully developed regions of the flow were investigated. The passage frequency of structures were found to

be 10-15 kHz in the developing region and 4-8 kHz in the fully developed region. The convective velocity obtained from the space-time correlation in the middle of the shear layer was close to the theoretical value but varied toward the edge of the shear layer. The structures were shown to be surprisingly three-dimensional even in this low compressibility level shear layer. The structures size and spacing were also determined and discussed. Author

A90-42731*# Pennsylvania State Univ., University Park.
COMPUTATION OF TURBINE FLOWFIELDS WITH A NAVIER-STOKES CODE
G. V. HOBSON and B. LAKSHMINARAYANA (Pennsylvania State University, University Park) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 17 p. refs
(Contract NSG-3266)
(AIAA PAPER 90-2122) Copyright

A new technique has been developed for the solution of the incompressible Navier-Stokes equations. The numerical technique, derived from a pressure substitution method (PSM), overcomes many of the deficiencies of the pressure crrection method. This technique allows for the direct solution of the actual pressure in the form of a Poisson equation which is derived from the pressure weighted substitution of the full momentum equations into the continuity equation. In two-dimensions a turbine flowfield, including heat transfer, has been computed with this method and the prediction of the cascade performance is presented. The extension of the pressure correction method for the solution of three-dimensional flows is also presented for laminar flow in an S-shaped duct and turbulent flow in the end-wall region of a turbine cascade. Author

A90-42732#
TURBULENT FLOW SIMULATION OF A THREE-DIMENSIONAL TURBINE CASCADE
D. C. CHAN and K. P. SHEEDY (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 14 p. Research supported by Rockwell International Corp. refs
(AIAA PAPER 90-2124) Copyright

A predictor-corrector finite volume Navier-Stokes solver has been employed to analyze the flow field inside a linear turbine cascade. Three grid resolutions ranging from approximately eighty thousand to two hundred thousand points have been used in an attempt to resolve the secondary flow inside the blade passage. Complicated three-dimensional flow features have been successfully captured inside the blade passage. The predicted total pressure loss has been found to be very sensitive to cross plane grid rsolution. Author

A90-42733#
ANALYSIS OF TRANSONIC TURBINE ROTOR CASCADE FLOWS USING A FINITE-VOLUME TOTAL VARIATION DIMINISHING (TVD) SCHEME
MARK A. DRIVER and PHILIP S. BERAN (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 17 p. refs
(AIAA PAPER 90-2127)

An explicit, time-accurate, two-dimensional, finite volume, Euler solver is developed with the capability of resolving the complex shock structure in a typical transonic rotor cascade. The current scheme uses the total variation diminishing (TVD) approach developed by Harten and extended to finite volume form by Yee. The rigor of the TVD approach has been extensively analyzed for one-dimensional scalar conservation laws, but the theory has not yet been fully extended to systems of conservation laws, either in one or two dimensions, and such an analysis is not attempted herein. However, numerical experimentation has shown correct physical behavior for the Riemann problem and dramatically enhanced resolution over other schemes. The computed solutions are compared with analytic solutions for a supersonic cascade of wedges and with experimental data for a high-work, low aspect ratio turbine. Author

A90-42734*# Cincinnati Univ., OH.
TRANSIENT BEHAVIOR OF SUPERSONIC FLOW THROUGH INLETS
H. S. PORDAL, P. K. KHOSLA, and S. G. RUBIN (Cincinnati, University, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 12 p. refs
(Contract NAG3-716; F49620-85-C-0027)
(AIAA PAPER 90-2130) Copyright

A solution technique to compute inlet flow behavior is presented. The phenomena of inlet unstart and restart are investigated using a flux-split procedure applied to the Euler and Reduced Navier Stokes (RNS) equations. A time consistent direct sparse matrix solver in conjunction with a domain decomposition strategy is applied to compute the transient flow behavior both internal and external to the inlet. Time varying shocks and time varying recirculation regions are efficiently analyzed. The code is quite general and is suitable for the computation of flow for a wide variety of geometries and over a wide range of Mach and Reynolds numbers. Author

A90-42735#
ANALYSIS OF SHOCK INTERACTIONS AND FLOW STRUCTURE IN HIGH SPEED INLETS
ARMEN DARIAN and ENDWELL O. DASO (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 11 p. refs
(AIAA PAPER 90-2132) Copyright

The performance of high-speed air-breathing propulsion systems such as scramjets and ramjets strongly depends on the efficiency of the inlet, which may be degraded, particularly at high Mach numbers, from shock-induced losses as well as losses resulting from shock/boundary-layer interactions (SBLIs) on walls. If SBLIs are severe, the wall flows may separate and could choke the core flow if the separation bubbles are reasonably large. Also, this could cause a serious problem if local thermal loads exceed material tolerance. It therefore becomes pertinent to assess the effects of shock/shock and SBLIs in high-speed inlets. Such an effort has been carried out here for a generic two-dimensional inlet with a large convergence angle. The flow structures of Mach 5 freestream Euler and viscous solutions are compared. The viscous solution shows strong SBLIs resulting in large separation bubbles with much higher temperatures on the wetted walls. In the inlet throat, the viscous flow structure gives the impression of a supersonic nozzle due to the presence of the separation bubbles; the flow decelerates through the nozzle to nearly Mach 2 and then recovers downstream to a value of about 4. Author

A90-42737#
COMPUTATIONAL ANALYSIS OF AN OPEN-NOSED FIGHTER/ATTACK INLET
R. G. SEMMES and R. M. WEYER (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 11 p. refs
(AIAA PAPER 90-2145)

A method for analyzing inlet systems is discussed and its ability to accurately assess important inlet performance characteristics is investigated. The method is based on the steady state flowfield predicted by a three-dimensional, fully viscous, Navier-Stokes code. The inlet performance characteristics investigated are spillage drag, pressure recovery, and aerodynamic interface plane (AIP) distortion indices. The inlet system investigated is the open nosed, fat lipped, S-duct of the YA-7F aircraft. The experimental results are derived from a 0.1 scale inlet and forebody tested at a freestream Mach number of 0.6 and corrected airflows of 180 and 235 lbs/sec. In general, the code did not yield sufficiently accurate total pressure values. Although reasonable bulk flowfield attributes such as static pressure and Mach number were derived, the total pressure

recoveries at the AIP were as much as 2 percent higher than experiment. This represents an unacceptable level of error for determining total pressure recovery and distortion characteristics for this type of inlet. Author

A90-42738#
ANALYSIS OF INSTALLED WIND TUNNEL TEST RESULTS ON LARGE BYPASS RATIO ENGINE/NACELLE INSTALLATIONS
J. S. SOKHEY (GE Aircraft Engines, Cincinnati, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 10 p. Research supported by the General Electric Co.
(AIAA PAPER 90-2146) Copyright

An analysis of wind tunnel test data from large bypass engine installations on a commercial aircraft is presented. The objective of this experimental study was to develop ultraslender and light weight nacelles for large turbofan engine (bypass ratio of 10 - 17) applications. Three through-flow nacelle models representative of several ultrahigh bypass engine configurations were selected for testing. Each nacelle (inlet and exhaust system) was designed for a realistic engine and to meet a set of inlet design requirements at take-off, engine out (windmill) and cruise operation. The nacelle placements with respect to wing were varied to provide their effect on the interference drag. The test data consisted of force balance measurements, and surface static pressures on nacelle, wing and pylon surfaces at various free-stream Mach numbers and angles of incidence. The isolated drag results indicate that these slender nacelles have low drag divergence Mach number (or early drag rise) due to large spillage and wave drag. However, this drag can be reduced significantly by modifying the crown region of nacelle forebody as data indicates. Author

A90-42748#
THE EFFECT OF SHOCK/SHOCK INTERACTIONS ON THE DESIGN OF HYPERSONIC INLETS
CHARLES A. LIND and MARK J. LEWIS (Maryland, University, College Park) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 12 p. refs
(AIAA PAPER 90-2217) Copyright

The type IV shock/shock interaction may result in localized regions with extremely high heating rates on the cowl of a hypersonic air-breathing engine. This is especially true because of the need to match the bow shock of a hypersonic vehicle with its engine cowl lip for efficient engine operation. Experimental and computational results have suggested that this interaction is inherently unsteady. One possible source of this unsteadiness is variations in the upstream flow properties. This work examines the effect that freestream variations have on the bow shock and on the shock/shock interaction which results when the inlet bow show intersects with the cowl bow shock. It is shown that slight perturbations in freestream conditions can have large effects on the TV shock/shock interaction flowfield. The sensitivity of the flowfield to changes in various upstream parameters is presented. Corresponding design rules for hypersonic inlets are suggested. Author

A90-42749*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A NUMERICAL STUDY OF THE EFFECTS OF REVERSE SWEEP ON A SCRAMJET INLET PERFORMANCE
AJAY KUMAR, CARL A. TREXLER (NASA, Langley Research Center, Hampton, VA), and D. J. SINGH (Analytical Services and Materials, Inc., Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 16 p. refs
(AIAA PAPER 90-2218)

A comparative numerical study of performance parameters of a similar and an opposite sweep sidewall compression inlet is made. The focus of the study is the investigation of the impact of alternate backward-forward sweep on the compression sidewalls as opposed to back-ward sweep on all the sidewalls. Two equivalent scramjet inlet configurations are designed for this purpose. These inlets have the same wetted areas of compression and expansion and same height and width; but in one inlet all the compression surface are swept back (similar sweep inlet) whereas in the other inlet, alternate surfaces are swept backward and forward (opposite sweep inlet). The cowl closure in both cases begins at the start of the throat region. A three-dimensional Navier-Stokes code is used to calculate the flow through these inlets. Results of these calculations are used to compare the two designs for their performance and flow quality. Effects of boundary-layer ingestion on the performance and overall flow features are also investigated. Author

A90-42750#
A COMPUTATIONAL MODEL FOR THICKENING BOUNDARY LAYERS WITH MASS ADDITION FOR HYPERSONIC ENGINE INLET TESTING
ROBERT D. CLAUSEN and PAUL A. KING (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 9 p. refs
(AIAA PAPER 90-2219)

A computational model for thickening boundary layers with mass addition to simulate the boundary layer developed on the forebody of hypersonic vehicles is developed. The phenomena of uniform normal injection into a two-dimensional supersonic stream and subsequent boundary layer growth downstream is discussed. An analysis of the injection region, which provides the thickness of the boundary layer just aft of injection, is combined with an approximate boundary layer velocity profile just aft of injection and input into a finite-difference boundary layer code which calculates downstream profiles and thicknesses. Comparisons are made with experimental results, and an example is discussed in which the natural boundary layer thickness is increased 17 times. Author

A90-42751#
A CFD STUDY OF PRECOMBUSTION SHOCK-TRAINS FROM MACH 3-6
L. G. HINTER and B. D. COUCH (General Dynamics Corp., Fort Worth, TX) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 27 p. refs
(AIAA PAPER 90-2220) Copyright

A CFD study of the shock-train behavior in a supersonic diffuser is described. The flow is assumed to interact with a downstream blocking device, and the free-stream Mach number is assumed to range from 3 to 10. A simplified viscous normal shock analysis shows that as the boundary layer thickens the downstream core Mach number is much nearer to Mach 1 than the inviscid solution and provides the mechanism for the flow to reaccelerate to supersonic conditions. High-speed shock trains appear to tunnel through the highly viscous transitional boundary layer and do not follow the isolator walls. Shock-on-shoulder inlet design philosophy creates a much more orderly shock train in the isolator with a relatively smooth pressure rise. C.D.

A90-42781#
FORCED RESPONSE ON TURBOMACHINERY BLADES DUE TO PASSING WAKES
S. H. CHEN and A. H. EASTLAND (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 12 p. refs
(AIAA PAPER 90-2353) Copyright

A frequency domain potential paneling method was used to study the forced response on turbomachinery blades. Forced response is unsteady due to the interaction between a blade and the viscous wake from an upstream blade row and the potential interactions when blade rows are closely spaced. Two cases typical of turbomachinery blade-wake interactions are investigated in this paper. One is the response of a compressor stator vane row swept by the wakes generated by rotating cylinders. The second one is the UTRC large scale turbine which has been used extensively to study rotor/stator aerodynamic and thermodynamic interactions. Lakshminarayana's wake model was employed in both

cases to generate the upstream blade wakes from which the unsteady response was calculated. Both test cases correlated the amplitude of response well with measurements. Author

A90-42783#
USING 3D EULER FLOW SIMULATIONS TO ASSESS EFFECTS OF PERIODIC UNSTEADY FLOW THROUGH TURBINES
RON-HO NI and OM SHARMA (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 8 p. refs
(AIAA PAPER 90-2357) Copyright

This paper presents numerical results from a number of steady and unsteady Euler flow simulations for a large scale low speed turbine model to provide an assessment on the effects of periodic unsteadiness in turbines. These results show that, for subsonic flow, periodic unsteadiness has little effect on the time-averaged pressure field. It is also shown that, through time-averaging, the unsteady flow simulation predicts a net segregation of hot/cold gas in rotor passages which is not predicted by conventional steady flow codes. This prediction demonstrates that an account of periodic unsteadiness is essential to quantify temperature levels on rotor airfoils in an engine environment. Author

A90-42784*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A VALIDATION STUDY OF THE SPARK NAVIER STOKES CODE FOR NONREACTING SCRAMJET COMBUSTOR FLOWFIELDS
DEAN R. EKLUND (National Research Council, Hampton, VA), G. BURTON NORTHAM (NASA, Langley Research Center, Hampton, VA), and DOUGLAS G. FLETCHER (NASA, Ames Research Center, Moffett Field, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 20 p. refs
(AIAA PAPER 90-2360) Copyright

A detailed study of Mach 2 flow over a rearward facing step and staged normal injection behind a rearward facing step into a Mach 2 mainflow has been performed using the Spark three-dimensional Navier-Stokes code. Very good overall agreement was observed for the flowfield without normal injection. The notable exceptions were the velocity for which the measured values showed more scatter and the temperature at the wall for which the value measured was below the adiabatic wall temperature. Faithful representation of the incoming boundary layer was found to be important in achieving good agreement. For the staged jet case, the calculated and measured flow quantities showed reasonably good agreement, with two significant discrepancies: the calculated jet trajectory is inclined more to the vertical then the measured one, and the measured temperatures downstream of the jets are lower than the computed ones. Possible reasons for the discrepancies are suggested. C.D.

A90-42872#
SUPERSONIC/HYPERSONIC LAMINAR/TURBULENT TRANSITION
HELEN REED, GREGORY STUCKERT, and PONNAMPALAM BALAKIMAR (Arizona State University, Tempe) IN: Developments in mechanics. Volume 15 - Midwestern Mechanics Conference, 21st, Houghton, MI, Aug. 13-16, 1989, Proceedings. Houghton, MI, Michigan Technological University, 1989, p. 43-53. Research supported by USAF, General Dynamics Corp., and McDonnell Douglas Corp. refs

Numerical simulation techniques being developed for hypersonic flow on two-dimensional and axisymmetric bodies (with application to the proposed National Aerospace Plane) are reviewed, and some preliminary results are summarized. The focus is on methods based on linear stability analysis, where the laminar flowfield is considered the basic state, and the growth/decay and amplitude of inherent perturbations propagating downstream are characterized. The disturbance state equations are obtained by linearizing the Navier-Stokes equations about the basic state. Particular attention is given to laminar instability and the transition to turbulence in the supersonic and hypersonic regimes, nonequilibrium chemistry effects, and three-dimensional basic states for the supersonic regime. T.K.

A90-42995
CALCULATION OF NONSEPARATED FLOW PAST A WING PROFILE AT LARGE REYNOLDS NUMBERS [O RASCHETE BEZOTRYVNOGO OBTEKANIIA KRYLOVOGO PROFILIA PRI BOL'SHIKH CHISLAKH REINOL'DSA]
S. A. VELICHKO and IU. B. LIFSHITS Prikladnaia Matematika i Mekhanika (ISSN 0032-8235), vol. 54, May-June 1990, p. 435-442. In Russian. refs
Copyright

A mathematical model describing nonseparated flow of an incompressible fluid past a wing profile at large Reynolds numbers is proposed which provides a way to determine the effect of viscosity on the aerodynamic characteristics. An analysis of the solution in the vicinity of the trailing edge makes it possible to formulate a refined analog of the Chaplygin-Zhukovskii condition. The accuracy of the results obtained is found to be comparable with that of experimental data. V.L.

A90-44005
SUBHARMONIC INSTABILITY OF COMPRESSIBLE BOUNDARY LAYERS
J. A. MASAD and A. H. NAYFEH (Virginia Polytechnic Institute and State University, Blacksburg) Physics of Fluids A (ISSN 0899-8213), vol. 2, Aug. 1990, p. 1380-1392. refs
(Contract N00014-85-K-0011)
Copyright

The subharmonic instability of a two-dimensional compressible boundary layer over an insulated flat plate is analyzed using the Floquet model. The resulting problem is solved numerically by using both finite differences and the computer code SUPORT. Results are presented for subsonic, transonic, and supersonic flows. For supersonic flows results for the first and second modes are presented. The effects of Mach number, spanwise wave number, amplitude of the primary wave, Reynolds number, and frequency are studied. Author

A90-44052
COMPRESSOR AERODYNAMICS
N. A. CUMPSTY (Cambridge, University, England) New York, John Wiley and Sons, Inc., 1989, 522 p. refs
Copyright

The basic principles of aerodynamic design for axial and radial compressors are discussed in an introduction for advanced students and practicing engineers. Chapters are devoted to general design considerations, throughflow on the hub-casing surface, blade-to-blade flows in axial compressors with subsonic and supersonic inlet flows, the centrifugal impeller, and the diffuser of the centrifugal compressor. Also examined are viscous effects in compressors; stall and surge; vibration and noise; and design, measurement, and computation. Extensive diagrams, drawings, graphs, and photographs are provided. T.K.

A90-44406
BOUNDARY INTEGRAL FORMULATION FOR COMPRESSIBLE NONLINEAR POTENTIAL AND NAVIER-STOKES EQUATIONS
ZUOSHENG YANG (Nanjing Aeronautical Institute, People's Republic of China) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 1. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 85-96. Research supported by the National Natural Science Foundation of China. refs
Copyright

Numerical techniques for the solution of (1) the nonlinear potential equation for strongly compressible flow and (2) the Navier-Stokes equations for compressible laminar flow are developed analytically in the framework of the boundary-integral method (BIM). Two BIM approaches to problem (1) are outlined, one involving analytic continuation to the complex plane and one

based on domain-integral elimination. For problem (2), the Navier-Stokes equation is decomposed (by solving the continuity, momentum, and energy equations separately) and reduced to a linear PDE with variable coefficients by a local linearization and splitting technique; the composite algebraic method of Vasilach (1979) is then applied to obtain a solution. BIM results for flows on a NACA 0012 airfoil and a swept M6 wing are presented in graphs and shown to be in good general agreement with published experimental data or numerical solutions. T.K.

A90-44407
NUMERICAL SIMULATION OF HYPERSONIC VISCOUS CONTINUUM FLOW
W. KORDULLA, S. RIEDELBAUCH, G. BRENNER, and B. MUELLER (DLR, Goettingen, Federal Republic of Germany) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 1. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 97-108. refs
Copyright

The simulation of laminar hypersonic flow is discussed based on the numerical integration of the time-dependent form of the Navier-Stokes equations. The air is assumed to exhibit perfect gas properties or to be in chemical equilibrium. For the assumption of perfect gases three-dimensional flows past a double-ellipsoid at a large angle of attack are discussed. For laminar flow in chemical equilibrium axisymmetrical blunt-body flows are considered. One approach uses the curve-fitting routines of Tannehill et al. to approximate the thermodynamic and transport properties of air at high temperatures. In the second approach the composition of the gas, and thus the thermodynamic properties, are directly computed from the reaction relations using the equilibrium constants. The transport coefficients for the assumed mixture of perfect gases are based on rigorous formulas for the single components. Author

A90-44426
DEVELOPMENT OF SUPERSONIC AND HYPERSONIC EULER SOLVERS USING SHOCK FITTING IN TWO AND THREE DIMENSIONS
C. M. BERGMAN (European Center for Research and Advanced Training in Scientific Computing, Toulouse, France), J. B. VOS (Lausanne, Ecole Polytechnique Federale, Switzerland), and A. W. RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 1. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 547-552. refs
Copyright

A finite-volume method with a central-difference scheme is used for the spatial discretization of the compressible Euler equations. Discontinuities are captured by adding artificial viscosity, using a blending of second- and fourth-order differences. The resulting system is integrated in time using an explicit multistage scheme. To increase the accuracy of the solution, a shock-fitting approach is used in which one mesh line or mesh surface is aligned with the external shock wave. The jump conditions over the shock are used to connect the upstream properties to those downstream. Calculation results for several examples are given, validating this approach both for ideal and real-gas flows. Author

A90-44430
A TWO-DIMENSIONAL UNSTEADY POTENTIAL SOLVER IN INTERNAL AERODYNAMICS FLOW PROBLEMS
M. HADZIDAKIS, P. CHAVIAROPOULOS, and K. D. PAPAILIOU (Athens, National Technical University, Greece) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 1. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 579-588. refs
Copyright

This paper presents an implicit, finite-difference algorithm, which solves the unsteady full potential equation in two dimensions, in conservation law form. The algorithm is applicable in internal flow configurations, where the unsteady character of the flow is due to the inlet and outlet time-dependent boundary conditions, while the geometry does not change in time. The governing equations are discretized in time by a second order accurate scheme and their solution is achieved by a two-step scheme that involves a linear and a non-linear time step. The method is applied in a typical duct configuration and results are presented and discussed covering a wide range of reduced frequencies in the subsonic flow region. Author

A90-44432
NUMERICAL STUDY OF HEAT TRANSFER FOR UNSTEADY VISCOUS SUPERSONIC BLUNT BODY FLOWS
F. PAVIE, J. B. CAZALBOU (ENSICA, Toulouse, France), A. KOURTA, and H. HA MINH (Ecole Nationale Superieure d'Electrotechnique, d'Electronique, d'Informatique et d'Hydraulique; European Center for Research and Advanced Training in Scientific Computing, Toulouse, France) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 1. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 595-600. refs
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The simulation of the flow field around an axisymmetric blunt body is performed by solving the full Navier-Stokes equations with the help of a finite volume method. The explicit-implicit method of MacCormack is applied to evaluate heat transfers on the solid body contour at supersonic speeds. The flux splitting procedure of Steger and Warming is included and an indirect line Gauss Seidel relaxation is used for inversion of the block matrix equation in the implicit stage. Numerical results are presented for the axisymmetric configuration with a uniform flow at Mach 3.0 assuming adiabatic or isothermal wall conditions. Author

A90-44433
NUMERICAL SIMULATION OF TRANSONIC POROUS AIRFOIL FLOWS
SHENG-JII HSIEH and LUNG-CHENG LEE (National Cheng Kung University, Tainan, Republic of China) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 1. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 601-608. refs
Copyright

A numerical simulation on transonic porous airfoil, with a cavity underneath, has been studied in conjunction with the problem of transonic wave drag reduction. The Euler equation is solved by finite volume method, and the Runge-Kutta multistage time stepping technique is used. The effect of porosity distribution on the upper surface, as well as on the lower surface of a NACA 0012 airfoil is examined carefully and the resultant aerodynamic lift and drag are computed. From the results of this study, it is found that the porosity distribution on the upper surface extending from 0.3 to 0.9, in tenths of chord from the leading edge, would apply to most of the transonic flight and have smaller wave drag and higher lift than those of a solid airfoil. Moreover, in addition to the above-mentioned porous upper surface, if a porous lower surface is used, with its cavity region extending from 0.1 to 0.7 (measured from leading edge and connecting to the upper surface cavity), then the resulting effects of the transonic wave drag reduction and the lift increment would be more pronounced. Author

A90-44434
SHOCK-FITTING IN THREE SPACE DIMENSIONS
GINO MORETTI (GMAF, Inc., Freeport, NY) and ROBERTO MARSILIO (Torino, Politecnico, Turin, Italy) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 1. Southampton, England and New York/Berlin, Computational

Mechanics Publications/Springer-Verlag, 1989, p. 609-616. refs
Copyright

A version of the lambda-scheme for integrating three-dimensional Euler equations for steady, supersonic flows is coupled to a logic for the handling of complex shock structure to provide a technique for shock-fitting in three space dimensions. Details of the technique are given and some typical shock pattern are shown, as obtained by the numerical analysis. Author

A90-44435
SOLUTION OF THE EULER EQUATIONS USING UNSTRUCTURED POLYGONAL MESHES

P. VANKIERSBILCK, R. STRUIJS, and H. DECONINCK (Von Karman Institute for Fluid Dynamics, Rhode-Saint-Genese, Belgium) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 1. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 617-624. Research supported by the European Project HERMES. refs
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An unstructured grid approach for solving the compressible flow equations is described, using a single data structure for polygonal finite volumes with arbitrary number of sides. This allows to combine patched grids of unstructured and structured type in a unified treatment well suited for solution adaptive refinement. Emphasis is put on the organization of the data structure needed to deal with complex geometries, ease of vectorization and solution adaptivity. Examples will be given from transonic to hypersonic flow cases. Author

A90-44437
NUMERICAL STUDY OF COMPRESSIBLE NOZZLE FLOW

A. NEBBACHE and D. ZEITOUN (Aix-Marseille I, Universite, Marseille, France) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 1. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 647-652. refs
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Laminar and turbulent flows in a convergent-divergent nozzle are studied numerically using the Navier-Stokes equations. The turbulent flow equations are closed by a modified Baldwin-Lomax turbulence model. A two step predictor corrector finite difference scheme is used to discretize the Navier-Stokes equations. In each step, an implicit procedure including the flux splitting technique is used to increase the Courant number. In a two-dimensional geometry, implicit operator requires the inversion of a block pentadiagonal matrix. This linear system is solved by different techniques which are compared. At the inlet of the nozzle the flow is subsonic and a particular attention must be paid for the treatment of this boundary condition, in order to avoid numerical instabilities in the convergence process. Author

A90-44439
FULLY VECTORIZED IMPLICIT SCHEME FOR 2-D VISCOUS HYPERSONIC FLOW USING ADAPTIVE FINITE ELEMENT METHODS

FRANCOISE ANGRAND (CEA, Villeneuve-Saint-Georges, France), JOCELYNE ERHEL (INRIA, Rennes, France), and PENELOPE LEYLAND (Lausanne, Ecole Polytechnique Federale, Switzerland) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 1. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 765-774. refs
Copyright

Two-dimensional viscous flow past a double ellipse geometry is simulated by an unfactored implicit scheme in time, using a centered approximation for the spatial discretization with unstructured P(1) triangular finite elements. A localized artificial viscosity term is introduced within the detached shock supersonic region; this, combined with adaptivity by local mesh refinement, reduces the spurious oscillations and overshoots, which are classical for centered approximations, without perturbing the subsonic layers. Author

A90-44447
A FORMULATION FOR THE SOLUTION OF EULER EQUATIONS FOR COMPRESSIBLE FLOW USING FINITE ELEMENTS

J. MIQUEL, E. ONATE, and F. QUINTANA (Cataluna, Universidad Politecnica, Barcelona, Spain) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 2. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 169-175. Research supported by CICYT. refs
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A formulation of the finite element solution of the Euler equations for compressible flow is presented which employs the basic Taylor-Galerkin/Petrov-Galerkin (TG/PG) upwinding techniques. It is shown that the TG and PG approaches can be reinterpreted in a unified form from which well known existing two-step schemes can be derived. Remarks are then made on the choice of permissible finite elements for subsonic cases or when the solution of blunt-nosed vehicles is attempted. In such cases the flow is nearly incompressible, and the simple linear extrapolation on a triangle for both velocity and pressure does not satisfy stability conditions for the mixed incompressible approximation forms. Examples are then presented of the application of the TG/PG formulation to the supersonic inviscid flow around an airfoil and the compressible flow around the nose of a space shuttle.
S.A.V.

A90-44459
TRANSONIC FLOW COMPUTATIONS IN CONVERGENT PROPULSION NOZZLES USING THE TIME-DEPENDENT MODE

K. KNOWLES (Royal Military College of Science, Shrivenham, England) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 2. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 435-441. refs
Copyright

A time-dependent method has been written for axisymmetric, transonic flows in convergent nozzles. Experiments with input variables and some of the boundary conditions have shown that the treatment of the nozzle lip mesh point has a marked effect on stability. The lip condition due to Cline is the most reasonable but produces, here, no better results than applying tangency. Two alternative jet boundary calculations have been tried but show little difference in terms of convergence or final results. In general, convergence is found to be particularly difficult for this problem. Results from other workers tend to support this. It is shown that swirling flows need be very carefully treated, especially the nozzle lip, if sound results are to be produced. Author

A90-44460
A MULTISTAGE METHOD FOR THE SOLUTION OF THE EULER EQUATIONS ON UNSTRUCTURED GRIDS

V. SELMIN (Aeritalia S.p.A., Turin, Italy) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 2. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 449-454. refs
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This paper introduces a multistage method which works on finite element type unstructured meshses. The spatial discretization is obtained by evaluating the integral version of the equations in a polygonal control volume constructed around each node of the finite element mesh. Steady state solutions are calculated by integrating the time dependent equations with a multistage time stepping scheme and by accelerating the convergence by means of residual averaging. Results of the computation of steady transonic flows are presented. Author

A90-44461
DEVELOPMENT AND APPLICATION OF A FRACTIONAL-STEP METHOD FOR THE SOLUTION OF TRANSONIC AND SUPERSONIC FLOW PROBLEMS
G. SIMANDIRAKIS, K. GIANNAKOGLOU, K. ALKALAI, and K. D. PAPAILIOU (Athens, National Technical University, Greece) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 2. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 455-463. refs
Copyright

A formulation for the numerical solution of two-dimensional viscous and inviscid flow fields is presented. Ths formulation is based on a fractional step numerical algorithm, while a simple algebraic turbulence model, that of Baldwin and Lomax, is used to effect closure in viscous flow problems. Body-fitted C- and H-type grids are used for the discretization of the governing equations past isolated airfoils or through plane cascades.
Author

A90-44601
NUMERICAL SOLUTION OF 2D TRANSONIC FLOWS IN A TURBINE CASCADE
MARIAN JURIK, KAREL KOZEL, and MIRKA VAVRINCOVA (Ceske Vysoke Uceni Technicke, Prague, Czechoslovakia) Acta Technica CSAV (ISSN 0001-7043), vol. 35, no. 3, 1990, p. 281-294. refs
Copyright

A method for numerically solving the inviscid steady subsonic and transonic flows through a two-dimensional cascade has been developed. The computation involves two modifications of the conservative finite volume formulation of the explicit predictor-corrector MacCormack difference scheme. Testing of the method by simulating the subsonic and transonic flow field in a turbine cascade for a shocked flow regime obtains results in good agreement with experimental data if a suitable mesh with refinement is used.
C.D.

A90-44727*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ZONAL NAVIER-STOKES METHODOLOGY FOR FLOW SIMULATION ABOUT A COMPLETE AIRCRAFT
JOLEN FLORES and NEAL M. CHADERJIAN (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, July 1990, p. 583-590. Previously cited in issue 17, p. 2774, Accession no. A88-43242. refs
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A90-44728#
EXPERIMENTAL STUDY OF THE TURBULENT BOUNDARY LAYER ON A TRANSPORT WING IN SUBSONIC FLOW
FRANK W. SPAID (McDonnell Douglas Research Laboratories, Saint Louis, MO) Journal of Aircraft (ISSN 0021-8669), vol. 27, July 1990, p. 591-598. refs
Copyright

The upper-surface boundary layer on a transport wing model was extensively surveyed with miniature yaw probes at a subsonic cruise condition. Significant variation in flow direction with distance from the surface was observed near the trailing edge, everywhere except at the wing root and tip. Values of streamwise displacement thickness, normalized by the local chord, were maximum at the highly loaded midsemispan stations. The data are intended to provide a test case for computational fluid dynamics code validation.
Author

A90-44733#
MINIMUM INDUCED DRAG FOR WINGS WITH SPANWISE CAMBER
MARTIN V. LOWSON (Bristol, University, England) Journal of Aircraft (ISSN 0021-8669), vol. 27, July 1990, p. 627-631. Previously announced in STAR as N90-18369. refs
Copyright

Linear theory is used to develop optimum circulation distributions and their associated minimum induced draf for wakes from lifting surfaces with arbitrary spanwise camber. The work is largely computational, and results for cases previously investigated analytically are generally in good agreement. Some previously published results are found to be in error, and a new solution for the induced drag of a wing with dihedral is given. New results are computed for polynomial and superelliptic camber lines which may be of practical interest. An empirical correlation is demonstrated between the induced drag factor and the inverse arc length for a variety of optimum cases. Conclusions are given which suggest that the most effective form of camber for given maximum displacement is the end plate, but elliptic and superelliptic shapes are slightly more effective in terms of minimum length of wing for a given displacement.
Author

A90-44739#
ITERATIVE ALGORITHM FOR CORRELATION OF STRAIN GAUGE DATA WITH AERODYNAMIC LOAD
GENE XU and MICHAEL WEST (Lockheed Engineering and Sciences Co., Houston, TX) Journal of Aircraft (ISSN 0021-8669), vol. 27, July 1990, p. 668-670.

The proposed approach to conversion of flight strain-gage data to aerodynamic loading employs a linear combination technique which assumes that the aerodynamic load on the structure can be represented on the basis of a set of polynomial shape functions over the wing surface. The measured strain gage data will reflect lift, drag, and side forces, as well as inertial force and thermal loading. The forces are simulated by distinguishing each individual contribution to the measured strain gage data; the shape functions used in the linear combination will then include all possible forces.
O.C.

A90-44740#
YAW DAMPING OF ELLIPTIC BODIES AT HIGH ANGLES OF ATTACK
WILLIAM B. BLAKE (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) and BILLY P. BARNHART (Bihrle Applied Research, Inc., Jericho, NY) Journal of Aircraft (ISSN 0021-8669), vol. 27, July 1990, p. 670-672. Previously cited in issue 06, p. 753, Accession no. A90-19664. refs

A90-44833#
ON AERODYNAMIC CHARACTERISTICS OF CANARD IN CARNARD-FORWARD-SWEPT WING CONFIGURATION
BINQIAN ZHANG (Northwestern Polytechnical University, Xian, People's Republic of China) and B. LASCHKA (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) Northwestern Polytechnical University, Journal (ISSN 1000-2758), vol. 8, July 1990, p. 327-334. In Chinese, with abstract in English. refs

The main aerodynamic problems of the overall configuration of canard-forward-swept wing (FSW) aircraft, including the flow separation at the root part and the interference between wing and canard, are discussed. It is found that the improvements of aerodynamic characteristics at high angles of attack depend on the relative location of wing nose vortex and canard nose vortex and their interaction. The canard should adopt a larger sweptback leading edge and a suitable forward-swept trailing edge. A close-coupled canard FSW configuration greatly improves the aerodynamic characteristics. When the double FSW configuration is adopted, the position of the canard should be vertically near the wing and horizontally far from the wing. This configuration appears inadvisable, because a separated flow area will appear at the canard root even though the flow separation at the wing root is eliminated. The canard improves the lateral aerodynamic characteristics of the FSW.
C.D.

A90-44922
NUMERICAL MODELING OF TRANSVERSE FLOW PAST A CYLINDER USING EULER EQUATIONS [CHISLENNOE MODELIROVANIE POPERECHNOGO OBTEKANIIA TSILINDRA NA OSNOVE URAVNENII EILERA]
IU. M. BELETSKII, P. A. VOINOVICH, IU. P. GOLOVACHEV, and

E. V. TIMOFEEV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 30, June 1990, p. 933-940. In Russian. refs
Copyright

The paper reports results of calculations of transverse nonviscous flow past a circular cylinder made by using a quasi-monotonic TVD scheme. The effect of scheme factors on the results of the numerical solution of Euler equations is investigated for subsonic, transonic, and supersonic velocities. The regimes considered include nonseparated flow, stationary flow with symmetric recirculation regions in the near wake and nonstationary separated flow. V.L.

A90-44928
EXCITATION AND DEVELOPMENT OF UNSTABLE PERTURBATIONS IN A SUPERSONIC BOUNDARY LAYER [VOZBUZHDENIE I RAZVITIE NEUSTOICHIVYKH VOZMUSHCHENII V SVERKHZVUKOVOM POGRANICHNOM SLOE]
V. R. GUSHCHIN and A. V. FEDOROV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), May-June 1990, p. 21-29. In Russian. refs
Copyright

The paper examines the initial boundary value problem concerning the development of two-dimensional inviscid perturbations excited by an external unsteady local action switched-on at a time moment t = 0. Using tyhe WKB method and numerical calculations, the spectrum of the problem is studied, and the asymptotic behavior of wave packets at t tending to infinity is investigated. It is shown that, contrary to the conclusion of Petrov (1988), the inviscid instability of a supersonic boundary layer is convective. The reasons for the divergence of results are examined. B.J.

A90-44930
THE POTENTIAL APPROXIMATION IN THE THEORY OF CONICAL FLOWS [O POTENTSIAL'NOM PRIBLIZHENII V TEORII KONICHESKIKH TECHENII]
IU. B. LIFSHITS and V. S. SAKOVICH Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), May-June 1990, p. 112-118. In Russian. refs
Copyright

A projection-grid method is used to integrate the conical-potential equations in connection with a problem involving shock generation in supersonic flow. Flow calculation results for circular and elliptical cones, a triangular plate, and a V-wing are compared with corresponding solutions of the Euler equations. The domain of the applicability of the potential model is established, and attention is given to the conditions under which the pressure-computation error increases. B.J.

A90-44931
EXPERIMENTAL INVESTIGATION OF TURBULENCE IN A SUPERSONIC FLOW [EKSPERIMENTAL'NOE ISSLEDOVANIE TURBULENTNOSTI V SVERKHZVUKOVOM POTOKE]
V. A. LEBIGA Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), May-June 1990, p. 119-124. In Russian. refs
Copyright

A dc hot-wire anemometer was used to investigate the structure of disturbances introduced in the working part of a supersonic wind tunnel at a Mach number of 2. Disturbances in front of the critical nozzle section were generated by a circular-rod cascade. The disturbances in the working part of the tunnel consisted of uncorrelated vortex, entropy, and acoustic modes; the first two modes were generated by the cascade while the acoustic mode was generated by the boundary layer on the nozzle walls. Owing to the cascade-generated turbulence, the position of the laminar-to-turbulent transition in the boundary layer varied greatly. B.J.

A90-44934
THE EFFECT OF VIBRATION-DISSOCIATION INTERACTION ON HEAT TRANSFER AND DRAG DURING THE HYPERSONIC FLOW PAST BODIES [VLIIANIE KOLEBATEL'NO-DISSOTSIATSIONNOGO VZAIMODEISTVIIA NA TEPLOPEREDACHU I SOPROTIVLENIE PRI GIPERZVUKOVOM OBTEKANII TEL]
S. V. ZHLUKTOV and G. A. TIRSKII Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), May-June 1990, p. 141-151. In Russian. refs
Copyright

The two-dimensional problem of hypersonic flow past blunt bodies is investigated in the framework of the full system of equations of a multicomponent viscous shock layer in chemical nonequilibrium. In particular, attention is given to steady flow past smooth axisymmetric blunt bodies at flight velocities of about 10 km/s for a wide range of altitudes above the earth surface, where nonequilibruium physical and chemical processes play a significant role (H = 50-100 km). The effect of vibration-dissociation interaction on flow and heat transfer in the shock layer is clarified. B.J.

A90-44935
AERODYNAMIC DRAG OF A PAIR OF BODIES IN TRANSONIC AND SUPERSONIC FLOW [OB AERODINAMICHESKOM SOPROTIVLENII PARY TEL PRI TRANS- I SVERKHZVUKOVOM OBTEKANII]
V. S. KHLEBNIKOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), May-June 1990, p. 152-156. In Russian. refs
Copyright

The paper presents an experimental study of the aerodynamic characteristics of models of pairs of rod-linked bodies in the acceleration and deceleration sections in transonic and supersonic flows. Experiments were carried out in an open wind tunnel in the Mach range of 0.5-1.7 and in the Re range of 10 to the 5th to 1.5 x 10 to the 6th. The dependence of the drag coefficient of the model on the relative drag of the leading body is determined for the supersonic-flow case. B.J.

A90-44936
DESIGN OF WING PROFILES FOR APPLICATION IN NONSTALL CONDITIONS IN A GIVEN ANGLE-OF-ATTACK RANGE [POSTROENIE KRYLOVYKH PROFILEI, OBTEKAEMYKH BEZOTRYVNO V ZADANNOM DIAPAZONE IZMENENIIA UGLOV ATAKI]
A. M. ELIZAROV and D. A. FOKIN Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), May-June 1990, p. 157-164. In Russian. refs
Copyright

The paper presents a general formulation of the inverse boundary value problem of aerohydrodynamics according to v(s) (velocity distribution as a function of the arc coordinate) for two angles of attack. An integral representation of the solution is obtained, and compatibility conditions for the initial data and the solvability condition are stated. A criterion for the absence of boundary layer separation on the wing profile for a given angle-of-attack range is obtained which is expressed through the velocity distribution under limiting conditions. The maximization of lift force is considered. B.J.

A90-45150#
TWO DIMENSIONAL POST STALL MANEUVER OF A NACA 0015 AIRFOIL AT HIGH PITCHING RATES
GARY M. GRAHAM (Ohio University, Athens) and KIM F. YEOW (Automated Analysis Corp., Peoria, IL) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 156-164. refs
(Contract AF-AFOSR-87-0312)
(AIAA PAPER 90-2810) Copyright

An experimental study of the aerodynamics of an NACA 0015 airfoil undergoing a two-dimensional poststall maneuver has been

conducted in the Ohio University tow tank facility. The maneuver consists of a ramp up-motion to a high angle of attack, a period of constant angle of attack motion, followed by a ramp down to the original angle of attack. Test results consist of force coefficient data and flow visualizations. The airfoil-dynamic stall vortex interaction during the ramp down motion was observed to have a significant effect on the airfoil loading. At pitch rates below a pitch rate of = 0.3, this interaction led to negative lift coefficients. For pitch rates above a pitch rate of = 0.3, the interaction resulted in significant recovery of lift during the ramp down motion. The effects of aerodynamic stall were observed to persist throughout the ramp down motion and, for a time, into the subsequent static motion. Author

A90-45153*# Notre Dame Univ., IN.
DELTA WING SURFACE PRESSURES FOR HIGH ANGLE OF ATTACK MANEUVERS
S. A. THOMPSON, S. M. BATILL, and R. C. NELSON (Notre Dame, University, IN) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 184-193. Research sponsored by the University of Notre Dame. refs
(Contract NAG1-727)
(AIAA PAPER 90-2813) Copyright

A wind tunnel experiment was performed on a delta wing with a leading edge sweep of 70 deg. Unsteady pressures were measured on the suction surface of the wing as it was oscillated from 0-30 deg, and 2-60 deg angle-of-attack. Pressure coefficients were measured at different surface locations for two pitch rates. Static pressure measurements were also obtained for comparison with the dynamic results. The Reynolds number was fixed at 420,000, based on the centerline chord length. Pressure measurements were made from 35-90 percent of the chord, along a ray from the apex at 60 percent of the local semispan. Spanwise measurements were also made at a constant chord location, x/c = 75 percent from the apex. The unsteady pressure data over the 0-30 deg angle-of-attack range showed pressures fluctuating in phase with model motion, and little overshoot from the static values. The pressures for the large amplitude motion showed large overshoots from the static values. In addition, during the high angle-of-attack portion of the motion, the upstroke (angle of attack increasing) pressure coefficients were typically much lower than the downstroke values. For the lower pitch rate, there was little difference between upstroke and downstroke pressures at the low angles of attack. Author

A90-45154*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CANARD-WING VORTEX INTERACTIONS AT SUBSONIC THROUGH SUPERSONIC SPEEDS
GARY E. ERICKSON (NASA, Langley Research Center, Hampton, VA), JOHN A. SCHREINER (NASA, Ames Research Center, Moffett Field, CA), and LAWRENCE W. ROGERS (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 194-221. refs
(AIAA PAPER 90-2814) Copyright

The NASA-Ames 6 x 6-foot Transonic/Supersonic Wind Tunnel has been used to conduct a study of canard-wing flowfield interactions at sub-, trans-, and supersonic speeds, giving attention to vortex interactions, vortex breakdown, shock-wave development, and vortex-shock interactions. The results obtained show that the canard-wing flowfield interaction delays vortex breakdown to a higher angle-of-attack at sub- and transonic speeds; while the flowfield interference eliminates shock-induced secondary boundary layer separation on the wing, it does not alter the location and development of a rear shock wave extending laterally across the wing. A canard-induced upwash field accelerates the upward migration of the wing vortex at sub-through-supersonic speeds, but is most pronounced at transonic speeds due to the interaction of the vortical flow with the rear shock wave. O.C.

A90-45155#
STEADY AND UNSTEADY FORCE TESTING OF FIGHTER AIRCRAFT MODELS IN A WATER TUNNEL
ATLEE M. CUNNINGHAM, JR. and TODD BUSHLOW (General Dynamics Corp., Fort Worth, TX) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 222-237. refs
(AIAA PAPER 90-2815) Copyright

The force testing of small-scale models in a water tunnel was investigated as an inexpensive and quick means to obtain static and dynamic force and moment data representative of full-scale fighter aircraft maneuvering in the poststall regime. Force tests of flat plate and three-dimensional full span models were conducted in a 24 x 24 sq in horizontal flow water tunnel using a special balance. Steady incidence sweeps and unsteady pitch-pulse motions up to a maximum angle of 90 deg were investigated for several planforms and models. Some specific objectives of this study were to: (1) verify that static and dynamic force and moment measurements from water tunnel testing were representative of large-scale wind tunnel tests; (2) demonstrate the importance of model three-dimensionality; (3) evaluate the effects of planform geometry; and (4) investigate dynamic stability and controllability aspects of the 'Cobra' maneuver performed by Pougachev in a Russian SU-27. Author

A90-45163#
AERODYNAMIC DESIGN CONSIDERATIONS FOR AIRCRAFT RADOMES
PAKRAD A. GIRAGOSIAN and SCOTT LOOS (Raytheon Co., Missile Systems Laboratories, Tewksbury, MA) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 316-325. refs
(AIAA PAPER 90-2843) Copyright

Parametric aerodynamic drag analyses based on semiempirical information developed through summarization and correlation of aerodynamic theory and experimental data for aircraft radomes were made. For simplicity, turbulent boundary layer flow properties were computed using classical power-law relationships (considering displacement and velocity distribution) along with the assumption for two-dimensional flow. Fineness ratio, frontal area, boat-tailing, beavertailing, boundary layer, Reynolds number effects, and location criteria were used as radome parameters. The impact of drag on flight performance, in terms of aircraft range degradation, is defined with the final result culminating in radome designs having a minimum impact on range. The radome design goal of achieving a required less than 1.0 percent aircraft range degradation was met for various aircraft using the methodology presented. Author

A90-45164#
CONTROL OF FOREBODY FLOW ASYMMETRY - A CRITICAL REVIEW
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 326-348. refs
(Contract F33615-87-C-3607)
(AIAA PAPER 90-2833) Copyright

The stability and control of advanced aircraft maneuvering of high angles of attack is often critically dependent upon the asymmetric flow separation with associated asymmetric vortices generated on a slender forebody. A review of existing experimental results has been performed to ascertain to what extent the asymetric forebody flow can be controlled. It is found that there exist many practical means by which the flow asymmetry can be eliminated. However, to develop means for reliable use of the flow asymmetry as a control device at high angles of attack is much more difficult. It appears that a great portion of the controlling effort has to be spent to develop a symmetric type of flow separation, which can be modulated in a controlled manner toward

the full flow asymmetry to provide the desired control characteristics. Author

A90-45165#
APPROACH TO SIDE FORCE ALLEVIATION THROUGH MODIFICATION OF THE POINTED FOREBODY GEOMETRY
V. J. MODI and A. C. STEWART (British Columbia, University, Vancouver, Canada) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 349-358. refs
(Contract NSERC-A-2181)
(AIAA PAPER 90-2834) Copyright

Aerodynamics of a circular cylinder with conical shaped forebodies is studied at a subcritical Reynolds number of around 100,000. Attention is primarily focused on modification of the forebody geometry to minimize the side force coefficient at high angles of attack. The tip geometries used are: the standard cone; a family of nose-booms; a set of delta strakes with porous tips; spinning nose-boom tips, and their combinations. The effectiveness of each tip in reducing the side force is assessed over a range of flight conditions, and compared with the standard tip data. The results suggest that such tip modifications can reduce the side force in the range of 50-88 percent. Author

A90-45166#
UNSTEADY FLOW SEPARATION ON SLENDER BODIES AT HIGH ANGLES OF ATTACK
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 359-366. refs
(Contract F33615-87-C-3607)
(AIAA PAPER 90-2835) Copyright

Experimental results for unsteady flow separation on slender bodies at high angles of attack are analyzed. The aim is to provide an understanding of the high-alpha unsteady fluid mechanics needed before the occurrence of asymmetric forebody flow separation with associated asymmetric vortices can be predicted. In this way, reliable means of control can be developed for maneuvering aircraft and missiles. Author

A90-45168#
AERODYNAMIC EFFECTS OF BODY ROUGHNESS
ASHER SIGAL (Technion - Israel Institute of Technology, Haifa) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 375-385. Research supported by the M. and A. Albert Fund for Research and Development in Aeronautical Engineering. refs
(AIAA PAPER 90-2850) Copyright

A modular model of a slender tangent-ogive-cylinder body having an interchangeable centerbody was tested alone, and in combination with a set of four fins, or with a flare, at Mach numbers of 0.8 and 2.4. The baseline centerbody was smooth. One centerbody was knurled and three were roughened by square threads of fixed height and of various pitch-to-height ratios. Centerbody roughness increased the normal-force-curve slope and shifted the center of pressure rearward for bodies alone and for body-flare combinations. In the case of the finned configurations, roughness caused small changes in the normal-force-curve slope and the center-of-pressure location. Qualitatively, the changes observed at the subsonic Mach number were the same as at the supersonic Mach number. Author

A90-45178#
A VOLTERRA KERNEL IDENTIFICATION SCHEME APPLIED TO AERODYNAMIC REACTIONS
JEFFREY C. TROMP and JERRY E. JENKINS (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) AIAA, Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990. 11 p. Research sponsored by USAF. refs
(AIAA PAPER 90-2803) Copyright

The application of a Volterra kernel identification scheme to the problem of modeling unsteady and nonlinear aerodynamic reactions over a two-dimensional airfoil is presented. A procedure originally developed to identify nonlinear behavior in electrical circuits is employed. This procedure has the advantage of using time domain input/output measurements to build the models. Of particular interest is the appearance of dirac-delta functions in the modeling of the aerodynamic reactions. This paper addresses in part the question of the applicability of the identification method to models that contain the delta function. Results from the identification of the first kernel, the linear impulse response function, are given. In addition, it is shown that the proposed form of the second Volterra kernel is sufficiently general to model delta function terms for a prescribed nonlinearity. Aerodynamic data from an unsteady Navier-Stokes code is used to provide data to build the linear model. Author

A90-45260
VISUALIZATION OF THE TURBULENT TRAILING VORTEX BEHIND A FINITE WING IN STEADY AND UNSTEADY FLOWS
X. LIANG (Tsinghua University, People's Republic of China) and B. R. RAMAPRIAN (Washington State University, Pullman) IN: Forum on turbulent flows - 1989; Proceedings of the Third Joint ASCE/ASME Mechanics Conference, La Jolla, CA, July 9-12, 1989. New York, American Society of Mechanical Engineers, 1989, p. 59-64. refs
(Contract DAAL03-87-G-0011)
Copyright

The trailing vortex in the near-field of a rectangular wing has been visualized using smoke and laser light sheet. The smoke photographs have been used to obtain qualitative and some quantitative information on the evolution of the vortex size in this region. Results are presented for the case of steady, as well as decelerating flows past the wing. In addition, some results are presented for the vortex evolution in the presence of an adverse longitudinal pressure gradient downstream of the wing. The experiments indicate that the vortex size in all cases depends on the angle of incidence but is not very sensitive to the pressure gradient downstream of the wing. The vortex growth is significantly enhanced by deceleration, only at angles of incidence at which flow detachment occurs on the wing. Vortex 'breakdown' was found to occur frequently in the presence of a sufficiently strong deceleration. Author

A90-45261
EFFECT OF RIBLETS ON FLOW SEPARATION IN A SUBSONIC DIFFUSER
P. I. KING, M. E. FRANKE (USAF, Institute of Technology, Wright-Patterson AFB, OH), and N. W. MARTENS IN: Forum on turbulent flows - 1989; Proceedings of the Third Joint ASCE/ASME Mechanics Conference, La Jolla, CA, July 9-12, 1989. New York, American Society of Mechanical Engineers, 1989, p. 79-83. refs
Copyright

Riblets are stream-direction grooves in a surface over which a fluid is flowing and have been shown to reduce turbulent skin friction drag in a localized area by as much as eight percent. The current tests are concerned with the effects of riblets on separation in an adverse pressure gradient. The adverse pressure gradient was generated in a plane-wall subsonic diffuser whose half-angle was ten degrees. The flow separated at various downstream locations depending on flow velocity and diffuser entrance height. Locations of flow separation were determined using oil drops and cotton tufts. Results indicated that riblets delay separation and are most effective for diffuser geometries which have the greatest likelihood of stalling. Author

A90-45323* United Technologies Research Center, East Hartford, CT.
AN UNSTEADY HELICOPTER ROTOR-FUSELAGE AERODYNAMIC INTERACTION ANALYSIS
PETER F. LORBER and T. ALAN EGOLF (United Technologies

Research Center, East Hartford, CT) American Helicopter Society, Journal (ISSN 0002-8711), vol. 35, July 1990, p. 32-42. Research supported by the U.S. Army. refs
(Contract NAS1-17469)
Copyright

A computational method has been developed to treat the unsteady aerodynamic interaction between a helicopter rotor, wake, and fuselage. Two existing codes, a lifting line-prescribed wake rotor analysis and a source panel fuselage analysis, were modified and coupled to allow prediction of unsteady fuselage pressures and airloads. A prescribed displacement technique was developed to position the rotor wake about the fuselage. Also coupled into the method were optional blade dynamics or rigid blade performance analyses to set the rotor operating conditions. Sensitivity studies were performed to determine the influence of the wake and fuselage geometry on the computational results. Solutions were computed for an ellipsoidal fuselage and a four bladed rotor at several advance ratios, using both the classical helix and the generalized distorted wake model. Results are presented that describe the induced velocities, pressures, and airloads on the fuselage and the induced velocities and bound circulation at the rotor. The ability to treat arbitrary geometries was demonstrated using a simulated helicopter fuselage. Initial computations were made to simulate the geometry of an experimental rotor-fuselage interaction study performed at the Georgia Institute of Technology. Author

A90-45325
EFFECTS OF UNSTEADY BLOWING ON THE LIFT OF A CIRCULATION CONTROLLED CYLINDER
TERENCE A. GHEE and J. GORDON LEISHMAN (Maryland, University, College Park) American Helicopter Society, Journal (ISSN 0002-8711), vol. 35, July 1990, p. 90-93. refs
Copyright

Experiments were performed to quantify the effects of unsteady blowing on the lift of a circulation controlled cylinder. Measurements were made of the time-dependent pressure at various locations around the cylinder and numerically integrated to find the sectional unsteady lift. The effects of blowing frequency were examined at a Reynolds number of 190,000 and for a slot angle of 90 deg. The results showed that the lift augmentation ratio was significantly increased above the static values by the effects of unsteady blowing. Significant lift hysteresis effects were also observed, and these effects increased with increasing blowing frequency. Author

A90-45423* Missouri Univ., Rolla.
SOME AERODYNAMIC CHARACTERISTICS OF THE SCISSOR WING CONFIGURATION
BRUCE P. SELBERG, KAMRAN ROKHSAZ, and CLINTON S. HOUSH (Missouri-Rolla, University, Rolla) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 9 p. refs
(Contract NAG1-975)
(SAE PAPER 892202) Copyright

A scissor wing configuration, consisting of four adjustable wing surfaces, is compared with a comparable fixed wing baseline configuration. Wave drag, induced drag, viscous drag, thrust required, and gust loading are calculated for both configurations. The scissor wing is shown to have lower zero lift wave drag and higher total lift to drag ratios than the baseline. It is demonstrated that the scissor configurations' sweep can be programmed to keep the static margin fixed. Thrust required for both the fixed static margin case and a constant sweep angle case are presented with the scissor configuration requiring lower thrust levels. The gust loading ratio of the scissor wing to the baseline is also shown to be significantly less than 1.0 for sweep angles greater than 20 degrees. Author

A90-45424* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE EFFECT OF SOLIDITY ON PROPELLER NORMAL FORCE
DANA MORRIS DUNHAM and GARL L. GENTRY, JR. (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 8 p. refs
(SAE PAPER 892205) Copyright

Propeller normal force is a major contributor to pitch and yaw stability on propeller driven aircraft. While it is well known that propeller normal force is a function of the number of blades, there are no published data for the high numbers of blades that are used in the new designs such as the UDF. This paper presents the results of a test conducted in the NASA Langley 14- x 22-foot Subsonic Tunnel using a sting-mounted counter-rotation propeller and nacelle. The configurations tested were combinations of 0, 4, and 8 blades per hub. Tests were conducted for blade angle settings of 31.34, 36.34, and 41.34 deg over an angle-of-attack range from -10 to 90 deg and over a range of advance ratios from 0.8 to 1.4. The results show that propeller normal force varies with both solidity and angle of attack. Author

A90-45439* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
IN-FLIGHT FLOW VISUALIZATION CHARACTERISTICS OF THE NASA F-18 HIGH ALPHA RESEARCH VEHICLE AT HIGH ANGLES OF ATTACK
DAVID F. FISHER, JOHN H. DEL FRATE (NASA, Flight Research Center, Edwards, CA), and DAVID M. RICHWINE (PRC System Services Co., Edwards, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 33 p. refs
(SAE PAPER 892222) Copyright

Surface and off-surface flow visualization techniques have been used to visualize the three-dimensional separated flows on the NASA F-18 high alpha research vehicle at high angles of attack. Results near alpha = 25 deg to 26 deg and alpha = 45 deg to 49 deg are presented. Both the forebody and leading-edge extension (LEX) vortex cores and breakdown locations were visualized using smoke. Forebody and LEX vortex separation lines on the surface were defined using an emitted-fluid technique. A laminar separation bubble was also detected on the nose cone using the emitted fluid technique and was similar to that observed in the wind-tunnel test, but not as extensive. Regions of attached, separated, and vortical flow were noted on the wing and the leading-edge flap using tufts and flow cones, and compared well with limited wind-tunnel results. Author

A90-45440* Vigyan Research Associates, Inc., Hampton, VA.
EFFECTS OF TURBULENCE MODELS ON THE PREDICTION OF TRANSONIC WING FLOWS
RIDHA ABID (Vigyan Research Associates, Inc., Hampton, VA) and DENNIS A. JOHNSON (NASA, Ames Research Center, Moffett Field, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 17 p. Research supported by NASA. refs
(SAE PAPER 892224) Copyright

An investigation of the effects of turbulence models on the prediction of transonic wing flows is performed. The turbulence models used in this study are the equilibrium model of Baldwin and Lomax, and the original and modified models of Johnson and King. Comparisons with experimental data are presented which show clearly that the modified Johnson-King model works much better than the equilibrium model. Author

A90-45452* Arizona State Univ., Tempe.
THE DEVELOPMENT OF CROSSFLOW VORTICES ON A 45 DEGREE SWEPT WING
MARC C. MOUSSEUX, WILLIAM S. SARIC, JON A. HOOS (Arizona State University, Tempe), and J. RAY DAGENHART (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 11 p. refs
(Contract NAG1-805; NAG1-937)
(SAE PAPER 892245) Copyright

Three-dimensional boundary-layer experiments are currently being conducted on a 45 deg swept wing in the Arizona State

University Unsteady Wind Tunnel. Crossflow-dominated transition is produced via a model with contoured end liners to simulate infinite swept-wing flow. Fixed-wavelength stationary and traveling crossflow vortex are observed. The stationary vortex wavelengths vary with Reynolds number as predicted by linear-stability theory, but with observed wavelengths which are about 25 percent smaller than theoretically predicted. The frequencies of the most-amplified moving waves are in agreement with linear-stability theory; traveling waves at higher frequencies than predicted are also observed. These higher-frequency waves may be harmonics of the primary crossflow waves generated by a parametric resonance phenomena. Boundary-layer profiles measured at several spanwise locations show streamwise disturbance profiles characteristic of the crossflow instability. Near the transition location, severe distortions of the laminar boundary-layer profiles are observed. Mean-profile measurements are compared to theoretical predictions. Author

A90-45465
A VSAERO ANALYSIS OF SEVERAL CANARD CONFIGURED AIRCRAFT. II
DAVID LEDNICER (Analytical Methods, Inc., Redmond, WA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 11 p. refs
(SAE PAPER 892287) Copyright

This paper reports on the analysis of several further canard configured aircraft using the VSAERO low-order panel method. Aircraft analyzed within include the Rutan VariEze, Defiant, Predator, Catbird and Triumph. In all cases VSAERO models of the complete aircraft have been used to calculate the aerodynamic performance of the aircraft. Comparisons of these results with flight test and wind tunnel data are included where data are available. Results presented herein show VSAERO to be reasonably accurate in predicting aircraft neutral point. Induced drag predictions tend to be inconsistent and future incorporation of a Trefftz Plane in VSAERO will probably rectify these problems. Overall, VSAERO is shown to be a useful tool for the aircraft design process. Author

A90-45466
APPLICATION OF DIVERGENT TRAILING-EDGE AIRFOIL TECHNOLOGY TO THE DESIGN OF A DERIVATIVE WING
R. D. GREGG, R. W. HOCH, and P. A. HENNE (Douglas Aircraft Co., Long Beach, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 15 p.
(SAE PAPER 892288) Copyright

The incorporation of divergent trailing-edge (DTE) technology into the design of a derivative wing is presented. The structural constraints imposed by the derivative approach will be reviewed with respect to their impact on the wing design. The predicted drag and buffet characteristics, derived using a combination of computational fluid dynamics (CFD) and empirically developed methods, are compared to wind tunnel measured characteristics. Calculated and measured results show a significant improvement in the performance of the derivative wing due to the integration of DTE airfoil technology. Author

A90-45467* Boeing Commercial Airplane Co., Seattle, WA.
TRANSONIC ANALYSIS OF COMPLEX CONFIGURATIONS USING TRANAIR PROGRAM
G. R. SAARIS, R. D. GILKEY, K. L. SMIT, and E. N. TINOCO (Boeing Commercial Airplanes, Seattle, WA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 11 p. refs
(Contract NAS2-12513)
(SAE PAPER 892289) Copyright

The application of a three-dimensional transonic flow analysis method, TRANAIR, is explored from the point of view of a user. Detailed features of the program are outlined to give a better understanding of capability. Numerous results are presented to show some of the complex configurations which have been analyzed. In particular, examples are provided which show the application to turbofan engine installation on transport aircraft. Author

A90-45473* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HYPERSONIC CFD APPLICATIONS FOR THE NATIONAL AERO-SPACE PLANE
PAMELA F. RICHARDSON, CHARLES R. MCCLINTON (NASA, Langley Research Center, Hampton, VA), ROBERT D. BITTNER, A. DOUGLAS DILLEY, KELVIN W. EDWARDS (Analytical Services and Materials, Inc., Hampton, VA) et al. SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 13 p. refs
(SAE PAPER 892310) Copyright

Design and analysis of the NASP depends heavily upon developing the critical technology areas that cover the entire engineering design of the vehicle. These areas include materials, structures, propulsion systems, propellants, integration of airframe and propulsion systems, controls, subsystems, and aerodynamics areas. Currently, verification of many of the classical engineering tools relies heavily on computational fluid dynamics. Advances are being made in the development of CFD codes to accomplish nose-to-tail analyses for hypersonic aircraft. Additional details involving the partial development, analysis, verification, and application of the CFL3D code and the SPARK combustor code are discussed. A nonequilibrium version of CFL3D that is presently being developed and tested is also described. Examples are given of portion calculations for research hypersonic aircraft geometries and comparisons with experiment data show good agreement. R.E.P.

A90-45474* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LOW-SPEED AERODYNAMIC CHARACTERISTICS OF A POWERED NASP-LIKE CONFIGURATION IN GROUND EFFECT
GREGORY M. GATLIN (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 12 p.
(SAE PAPER 892312) Copyright

Results are presented on the low-speed aerodynamic characteristics of a simplified NASP (for National Aerospace Plane Program)-like configuration, obtained in the NASA-Langley 14-by-22-foot subsonic tunnel. The model consisted of a triangular wedge forebody, a rectangular midsection housing the propulsion simulation system, and a rectangular wedge aftbody; it also included a delta wing, exhaust flow deflectors, and aftbody fences. Flow visualization was obtained by injecting water into the engine simulator inlets and using a laser light sheet to illuminate the resulting exhaust flow. It was found that power-on ground effects for NASP-like configuration can be substantial; these effects can be reduced by increasing the angle-of-attack to the value of the aftbody ramp angle. Power-on lift losses in ground effect increased with increasing thrust, but could be reduced by the addition of a delta wing to the configuration. Power-on lift losses also increased with use of aftbody fences. I.S.

A90-45477* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A MACH 6 EXTERNAL NOZZLE EXPERIMENT WITH ARGON-FREON EXHAUST SIMULATION
JAMES L. PITTMAN (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 11 p. refs
(SAE PAPER 892315) Copyright

A scramjet exhaust simulation technique for hypersonic wind tunnel testing has been developed. Mixtures of Argon and Freon correctly match the inviscid simulation parameters of Mach number, static-pressure ratio, and the ratio of specific heats at the combustor exit location; this simulation is accomplished at significantly reduced temperatures and without combustion. An investigation of nozzle parametrics in a Mach 6 freestream showed that the external nozzle ramp angle, the cowl trailing-edge angle, an external nozzle flow fence and the nozzle static-pressure ratio significantly affected the external nozzle thrust and pitching moment as measured by the integration of surface-pressure data. A comparison of Argon-Freon and air exhaust simulation showed that the external

nozzle thrust and pitching moment were in error by roughly a factor of 2 using air due to the incorrect match of the ratio of specific heats. An assessment of two-dimensional Euler and Navier-Stokes codes for predicting external nozzle aerodynamic characteristics was made by comparing computed and experimental results. Author

A90-45481
A NONLINEAR TRANSIENT FORMULATION OF UHB AEROELASTIC RESPONSE AND STABILITY. I - THEORETICAL FORMULATION
RON D'VARI and KRISHNA HOFFMAN (Douglas Aircraft Co., Long Beach, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 21 p. refs
(SAE PAPER 892322) Copyright

A nonlinear transient coupled flap-lag-torsion aeroelastic response and stability analysis of articulated counterrotating Ultra High Bypass fans is presented. Hinged or elastic blade retention systems with arbitrarily oriented axes are allowed. Additional features include pitch control flexibility, arbitrary pretwist, presweep, and precone of the blade root and spanwise distribution of large blade sweep, droop and pretwist angles. The symbolic derivation of the equations of motion avoids explicit algebraic expansions of the velocity and acceleration vectors. The numerical implementation of the symbolic equations, combined with the state variable form of the equations, makes it easy to change geometric features, add new flexible elements, and extend the analysis to the coupled rotor/fuselage case without additional effort. A 15-th order finite-state two-dimensional cascade aerodynamic model has been used. The analysis allows the study of the effects of transient and/or nonuniform axial and tangential flows, blade dissimilarities and harmonic pitch control inputs. Author

A90-45495* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INDUCED DRAG - HISTORICAL PERSPECTIVE
WILLIAM P. HENDERSON and BRUCE J. HOLMES (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 25 p. refs
(SAE PAPER 892341) Copyright

Induced drag is associated with the shedding of vorticity along the span of a finite wing, especially its tip region; for most subsonic aircraft configurations, induced drag constitutes about 50 percent of total aircraft drag throughout the flight envelope. NASA and the U.S. aircraft industry have aggressively studied induced-drag reduction methods. The state-of-the-art CTOL commercial aircraft wing is as a result of these efforts virtually optimal, with a total induced drag lying within a percent of the theoretical minimum. Many of the devices currently under study for induced drag reduction are added to wingtips, yielding benefits through their effects on the wake vortex as well as through forces generated in the flowfield. O.C.

A90-45496*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN ENTROPY METHOD FOR INDUCED DRAG MINIMIZATION
GEORGE C. GREENE (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 12 p. refs
(SAE PAPER 892344)

A fundamentally new approach to the aircraft minimum induced drag problem is presented. The method, a 'viscous lifting line', is based on the minimum entropy production principle and does not require the planar wake assumption. An approximate, closed form solution is obtained for several wing configurations including a comparison of wing extension, winglets, and in-plane wing sweep, with and without a constraint on wing-root bending moment. Like the classical lifting-line theory, this theory predicts that induced drag is proportional to the square of the lift coefficient and inversely proportioinal to the wing aspect ratio. Unlike the classical theory, it predicts that induced drag is Reynolds number dependent and that the optimum spanwise circulation distribution is non-elliptic. Author

A90-45497* Grumman Aerospace Corp., Bethpage, NY.
HYPERSONIC FOREBODY LIFT-INDUCED DRAG
C. W. BOPPE and W. H. DAVIS (Grumman Corp., Aircraft Systems Div., Bethpage, NY) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 12 p. Research supported by NASA. refs
(SAE PAPER 892345) Copyright

The dominance of body-like shapes for hypersonic vehicles places emphasis on better understanding of pertinenet body flow physics. Computational methods are implemented to enhance the knowledge of drag components generated by the production of lift forces at hypersonic speeds. Three forebody shapes are examined to identify the effects related to body shape parameters. A Navier-Stokes code and classical Newtonian theory code provide predictions of the polar shapes upon which conclusions are drawn. In particular, it is noted that hypersonic body polar shapes are somewhat irregular; the result of incidence-induced form drag. Test data which supports this finding is identified. The means for reducing hypersonic body lift-induced drag are also identified, along with applied computational schemes that can reduce the cost of a configuration design program. Author

A90-45498* Tennessee Univ. Space Inst., Tullahoma.
VORTICAL SOURCES OF AERODYNAMIC FORCE AND MOMENT
J. Z. WU and J. M. WU (Tennessee, University, Tullahoma) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 13 p. refs
(Contract NAG1-844)
(SAE PAPER 892346) Copyright

It is shown that the aerodynamic force and moment can be expressed in terms of vorticity distribution (and entropy variation for compressible flow) on near wake plane, or in terms of boundary vorticity flux on the body surface. Thus the vortical sources of lift and drag are clearly identified, which is the real physical basis of optimal aerodynamic design. Moreover, these sources are highly compact, hence allowing one to concentrate on key local regions of the configuration, which have dominating effect to the lift and drag. A detail knowledge of the vortical low requires measuring or calculating the vorticity and dilatation field, which is however still a challenging task. Nevertheless, this type of formulation has some unique advantages; and how to set up a well-posed problem, in particular how to establish vorticity-dilatation boundary conditions, is addressed. Author

A90-45522* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATIONAL RESULTS FOR THE EFFECTS OF EXTERNAL DISTURBANCES ON TRANSITION LOCATION OF BODIES OF REVOLUTION FROM SUBSONIC TO SUPERSONIC SPEEDS AND COMPARISONS WITH EXPERIMENTAL DATA
S. H. GORADIA, P. J. BOBBITT, and W. D. HARVEY (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 18 p. refs
(Contract NAS1-18585)
(SAE PAPER 892381) Copyright

Computational experiments have been performed for a few configurations in order to investigate the effects of external flow disturbances on the extent of laminar flow and wake drag. Theoretical results have been compared with experimental data for the AEDC cone, for Mach numbers from subsonic to supersonic, and for both free flight and wind tunnel environments. The comparisons have been found to be very satisfactory, thus establishing the utility of the present method for the design and development of laminar flow configurations and for the assessment of wind tunnel data. In addition, results of calculations concerning the effects of unit Reynolds numbers on transition are presented. In addition to the AEDC cone, computations have been performed for an ogive body of revolution at zero angle of attack and

supersonic Mach numbers. Results are presented for transition Reynolds number and wake drag for external disturbances corresponding to free air and the test section of the AEDC-VKF tunnel. These results have been found to compare quite well with wind tunnel data for cases when surface suction is applied as well as when suction is absent. Author

A90-45536
NUMERICAL SOLUTIONS FOR UNSTEADY AEROFOIL BY INTERNAL SINGULARITY METHOD
M. J. SHEU (National Tsing Hua University, Hsinchu, Republic of China) and D. R. CHEN IN: Recent advances in computational fluid dynamics; Proceedings of the US/ROC (Taiwan) Joint Workshop, Princeton, NJ, May 23-25, 1988. Berlin and New York, Springer-Verlag, 1989, p. 420-436. refs
Copyright

An internal singularity method has been developed for the calculation of the vortex wake pattern, the pressure distribution, lift, drag, and moment on a two-dimensional aerofoil undergoing unsteady motion in an inviscid incompressible flow. This method does not have the disadvantages of the internal singularity methods developed by Basu et al. and Chen et al. The Kutta condition of no loading at the trailing edge and the condition that the wake can not sustain any pressure difference are used to obtain a satisfactory solution. This method is applied to 8.4-percent thick symmetrical Von Mises aerofoil, oscillating in pitching and heaving at high reduced frequency. The results show that the nonlinear wake effect on the unsteady aerodynamic properties is significant. Author

A90-45727
NON-UNIQUE SOLUTIONS OF THE EULER EQUATIONS
G. BARUZZI, W. G. HABASHI, and M. M. HAFEZ IN: Advances in fluid dynamics. New York, Springer-Verlag, 1989, p. 1-10. refs
Copyright

In this paper, finite element (FE) solutions of the Euler equations are obtained using an artificial viscosity method. Considering a two-dimensional, symmetric, convergent-divergent nozzle with a smooth area variation, the numerical FE solution demonstrates the nonuniqueness problem under the same conditions predicted by the quasi-one-dimensional finite difference analysis. The stability of the two-dimensional shocks is studied by solving the truly unsteady Euler equations with a backward Euler finite difference discretization of the time-dependent terms. At each time step, the four equations are solved fully coupled, in a manner similar to the steady-state approach. Shocks are caused around the steady-state position, and the shock motion is examined for each case. C.D.

A90-45738
SOME REMARKS ON THE KUTTA CONDITION
KOICHI OSHIMA IN: Advances in fluid dynamics. New York, Springer-Verlag, 1989, p. 218-227. refs
Copyright

The applications of the Kutta condition to the study of unsteady flows, discrete vortex methods, and three-dimensional flows are briefly reviewed. The major research findings in each of these areas are summarized. Remaining difficulties are pointed out. C.D.

A90-45740
TRAJECTORIES OF VORTEX LINES BENEATH A FREE SURFACE OR ABOVE A PLANE
B. YIM IN: Advances in fluid dynamics. New York, Springer-Verlag, 1989, p. 275-283. refs
Copyright

The trajectories of the tip vortex lines resulting when an airfoil moves in the air above the ground are studied first as an unsteady problem (with the wake shape being found at each time step), and then by considering the solution away from the end points of the vortex line. The velocity of the vortex line is obtained by the Biot-Savart law in three-dimensional space and by the complex potential in two-dimensional space. The trajectories of the vortex lines are obtained by solving the simultaneous ordinary differential equations with the Runge-Kutta method. The computational results obtained by the two- and three-dimensional analyses are compared. C.D.

A90-45760
UNSTEADY TRANSONIC FLOW
MARTEN T. LANDAHL (MIT, Cambridge, MA) Research supported by Swedish Air Board and USAF. Cambridge, England and New York, Cambridge University Press, 1989, 142 p. refs
Copyright

The analysis of unsteady lift distributions of thin oscillating wings at transonic speeds is discussed for various kinds of wings. The types of wing planforms considered include: low-aspect ratio wings of triangular and related planforms, low aspect ratio rectangular wing, low aspect ratio wing-body combinations, semiinfinite rectangular wing, rectangular wing of arbitrary aspect ratio with control surface, delta wing of arbitrary aspect ratio, and general planform wings. Control surface buzz is considered, as is the experimental determination of air forces on oscillating wings at transonic speeds. C.D.

A90-45783* City Coll. of the City Univ. of New York, NY.
LINEAR INSTABILITY OF THE SUPERSONIC WAKE BEHIND A FLAT PLATE ALIGNED WITH A UNIFORM STREAM
D. T. PAPAGEORGIOU (City College, New York) Theoretical and Computational Fluid Dynamics (ISSN 0935-4964), vol. 1, no. 6, 1990, p. 327-348. refs
(Contract NAS1-18605)
Copyright

A theoretical and numerical study is presented of the growth of linear disturbances in the laminar compressible supersonic wake behind a flat plate aligned with a uniform stream. The approach adopted is that of classical linear stability theory and covers both two- and three-dimensional disturbances. The basic flow is described, and the linear stability problem is formulated that leads to the compressible Rayleigh equation. The stability of short-wave disturbances is then analyzed in the very near wake where the compressible analog of the Goldstein double structure provides an asymptotic description for the unperturbed flow. The behavior of long waves is then considered. The waves are not as long as the plate length but are long compared to the boundary-layer thickness. Numerical solutions of the Rayleigh equation are discussed. Numerical results are then presented for a range of streamwise stations, Mach numbers, and wave propagation angles. S.A.V.

A90-45785* Vigyan Research Associates, Inc., Hampton, VA.
SIMULATION OF LEADING-EDGE VORTEX FLOWS
C.-H. HSU (Vigyan, Inc., Hampton, VA) and C. H. LIU (NASA, Langley Research Center, Hampton, VA) Theoretical and Computational Fluid Dynamics (ISSN 0935-4964), vol. 1, no. 6, 1990, p. 379-390. refs
(Contract NAS1-18585)
Copyright

An implicit upwind-relaxation finite-difference algorithm solving the incompressible Navier-Stokes equations is employed to simulate low-speed, three-dimensional, laminar, leading-edge vortex flows over three round-edged low-aspect-ratio wings. The effects of grid density, angle of attack, Reynolds number, and wing planform on the flowfield structures and integral values are studied. Computed results are presented and compared with experimental data. Author

N90-25110*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INTEGRAL-EQUATION METHODS IN STEADY AND UNSTEADY SUBSONIC, TRANSONIC AND SUPERSONIC AERODYNAMICS FOR INTERDISCIPLINARY DESIGN
E. CARSON YATES, JR. May 1990 18 p Presented at the Japan/USA Boundary Elements Symposium, Palo Alto, CA, 5-7 Jun. 1990
(NASA-TM-102677; NAS 1.15:102677) Avail: NTIS HC A03/MF A01 CSCL 01/1

Progress in the development of computational methods for steady and unsteady aerodynamics has perennially paced advancements in aeroelastic analysis and design capabilities. Since these capabilities are of growing importance in the analysis and design of high-performance aircraft, considerable effort has been directed toward the development of appropriate aerodynamic methodology. The contributions to those efforts from the integral-equations research program at the NASA Langley Research Center is reviewed. Specifically, the current scope, progress, and plans for research and development for inviscid and viscous flows are discussed, and example applications are shown in order to highlight the generality, versatility, and attractive features of this methodology. Author

N90-25111*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
COUPLED ROTOR-BODY EQUATIONS OF MOTION HOVER FLIGHT Interim Report, 2 Feb. 1989 - 30 Jun. 1990
H. C. CURTISS, JR. and R. M. MCKILLIP, JR. Jun. 1990 47 p (Contract NAG2-561)
(NASA-CR-186710; NAS 1.26:186710; PU-TR-1894T) Avail: NTIS HC A03/MF A01 CSCL 01/1

A set of linearized equations of motion to predict the linearized dynamic response of a single rotor helicopter in a hover trim condition to cyclic pitch control inputs is described. The equations of motion assume four fuselage degrees of freedom: lateral and longitudinal translation, roll angle, pitch angle: four rotor degrees of freedom: flapping (lateral and longitudinal tilt of the tip path plane), lagging (lateral and longitudinal displacement of the rotor plane center of mass); and dynamic inflow (harmonic components). These ten degrees of freedom correspond to a system with eighteen dynamic states. In addition to examination of the full system dynamics, the computer code supplied with this report permits the examination of various reduced order models. The code is presented in a specific form such that the dynamic response of a helicopter in flight can be investigated. With minor modifications to the code the dynamics of a rotor mounted on a flexible support can also be studied. Author

N90-25112*# Old Dominion Univ., Norfolk, VA. Dept. of Mathematical Sciences.
A REVIEW OF INSTABILITY AND NOISE PROPAGATION IN SUPERSONIC FLOWS Final Report, period ending 31 May 1990
Q. ISA DAUDPOTA and WILLIAM D. LAKIN Jul. 1990 32 p (Contract NAG1-881)
(NASA-CR-186800; NAS 1.26:186800) Avail: NTIS HC A03/MF A01 CSCL 01/1

Originally analytical and numerical models were to be developed for noise production in supersonic jets, wakes and free shear layers. While the effort was concentrated initially on these aspects, other topics were also pursued, most were of interest to the Jet Noise Group of the Aeroacoustics Branch. An overview is given of subjects reviewed and the investigations that were carried out. A significant effort was devoted to numerically predicting the flow field of a turbulent supersonic wall jet. This information is necessary for computing the pressure in the far field. The wall jet was selected because it represents a generic flow that can be associated with plug nozzle in supersonic engines. It combines the characteristic of a boundary layer with that of a free shear flow. The spatially evolving flow obtained using Dash's code would form the input for the stability analysis program. This analysis would determine the large scale instability wave within the flow. The far field pressure can be computed from the shape of the evolving large scale structure by asymptotic methods. Flow characteristics obtained from a program that analyses the turbulent downstream supersonic flow in a nozzle are described and compared with experimental results. Author

N90-25113# European Space Agency, Paris (France).
A LIFTING SURFACE METHOD FOR THE CALCULATION OF STEADY AND UNSTEADY, INCOMPRESSIBLE PROPELLER AERODYNAMICS
JUERGEN SCHOENE (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick, Germany, F.R.) May 1990 145 p Transl. into ENGLISH from Ein Tragflaechenverfahren zur Berechnung Stationaerer und Instationaerer, Inkompressibler Propellerumstroemung (Brunswick, Fed. Republic of Germany, DFVLR), Jan. 1989 120 p Original language document was announced as N89-25972
(ESA-TT-1151; DFVLR-FB-89-04; ETN-90-97075) Avail: NTIS HC A07/MF A01

A lifting surface method for steady and unsteady propeller flows which enables ascertainment of load distribution on blades of axial-flow individual and counter-rotating propellers is presented. Initially, Prandtl's acceleration potential is referred to for an integral equation for non-chorded lifting surfaces with time-dependent load distribution. Next a method is developed for numerical solution of this equation; for this purpose the lifting surfaces of the propeller blades are divided into panels over which doublets are arranged in a line. The chronologically-varying intensity of these singularities is developed in a Fourier series. Consequently a linear equation system has to be solved, rather than an integral equation. The method was validated by extensive specimen and comparative calculations. Results for wings in straight-line motion, single propellers with steady and unsteady load distributions and for counter-rotating propellers, are presented. ESA

N90-25114# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
AN EXPERIMENTAL AND THEORETICAL INVESTIGATION OF THE FLOW OVER PLANE DELTA WINGS WITH SUPERSONIC LEADING EDGES
A. C. J. VENIS Jun. 1989 79 p
(LR-588; ETN-90-97162) Avail: NTIS HC A05/MF A01

The experimental and theoretical investigation of the flow on both the windward and the leeward side of a supersonic plane delta wing is covered. An experimental test program, on unyawed and yawed delta wings, consisting of surface pressure tests, oil flow tests and pilot-pressure tests, was performed. The theoretical approach is based on a recently developed theory of conical stagnation point solutions. This approach implies the embedding of a local flow solution in a surrounding known flow field. The computer code is implemented and is used in connection with the test series. The agreement of the flow calculations with the experimental data is good. At higher angles of attack the agreement was found to be less accurate. On the wing leeward side the flow is found to be locally shock induced separated for higher angles of attack. The theory is extended to the calculation of the flow over the surface of yawed delta wings. A third order approximation is obtained for the flow over the wing windward side. However, for the flow on the leeward side of the yawed delta wing no satisfactory solution for a general case was obtained. The simple procedure of matching the local solutions to the surrounding flow in a chosen set of specific points yields equations that cannot be solved in all but a few incidental cases. The calculations on the wing windward side are found to be consistent with experimentally obtained data. Experiments are performed on the wing leeward side although no proper comparison with theory is made. ESA

N90-25115# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
INVESTIGATION OF THE VORTEX FLOW OVER A SHARP-EDGED DELTA WING IN THE TRANSONIC SPEED REGIME
W. J. BANNINK, E. M. HOUTMAN, and S. P. OTTOCHIAN Oct. 1989 66 p
(LR-594; ETN-90-97164) Avail: NTIS HC A04/MF A01

An experimental investigation of high subsonic and transonic flow at the leeside of a sharp edged planar delta wing, having a leading edge sweep of 65 deg is presented. The experiments were performed at Mach numbers from 0.6 to 0.9 and angles of attack up to 20 deg. Surface pressure measurements, oil flow visualizations and Schlieren visualizations were made. Attention was paid to the presence and location of embedded shock waves, vortex breakdowm and the interaction of these two phenomena.

The status of the boundary layer on the leesurface of the wing was considered. Special emphasis was given to the case with a free stream Mach number of 0.85 since this case attracted special international interest in relation to computer validation. The present experiments did not reveal how the two observed shocks extended in spanwise direction, nor did they show the existence of other embedded shocks (oblique to the free stream direction) measured in earlier investigations by flow field explorations. ESA

N90-25116# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
THE APPLICATION OF THE FINITE ELEMENT METHOD TO AN AERODYNAMIC PROBLEM SPECIFIC TO PROPELLER DESIGN
CYRIL M. WENTZEL Mar. 1990 58 p
(LR-614; ETN-90-97177) Avail: NTIS HC A04/MF A01

A finite element method was applied and programmed for the solution of a classical problem occurring in propeller aerodynamics: finding the optimum circulation distribution (minimum energy loss in the wake). No specific numerical problems were encountered and the method was verified (linear elements) using classical tables in the literature. The program yields an efficient and flexible means of generating the optimum distribution for open propellers of arbitrary bladenumber and for any advance coefficient. The applicability of this finite element model to ducted propeller theory is explored. ESA

N90-25934*# Case Inst. of Tech., Cleveland, OH. Dept. of Mechanical and Aerospace Engineering.
INTERACTIVE CALCULATION PROCEDURES FOR MIXED COMPRESSION INLETS Final Technical Report
ELI RESHOTKO Mar. 1983 7 p
(Contract NAG3-140)
(NASA-CR-186581; NAS 1.26:186581) Avail: NTIS HC A02/MF A01 CSCL 01/1

The proper design of engine nacelle installations for supersonic aircraft depends on a sophisticated understanding of the interactions between the boundary layers and the bounding external flows. The successful operation of mixed external-internal compression inlets depends significantly on the ability to closely control the operation of the internal compression portion of the inlet. This portion of the inlet is one where compression is achieved by multiple reflection of oblique shock waves and weak compression waves in a converging internal flow passage. However weak these shocks and waves may seem gas-dynamically, they are of sufficient strength to separate a laminar boundary layer and generally even strong enough for separation or incipient separation of the turbulent boundary layers. An understanding was developed of the viscous-inviscid interactions and of the shock wave boundary layer interactions and reflections. Author

N90-25935 Toronto Univ (Ontario). Inst. for Aerospace Studies.
PREDICTION OF TWO-DIMENSIONAL TIME-DEPENDENT GASDYNAMIC FLOWS FOR HYPERSONIC STUDIES
D. F. HAWKEN (Viatec Resource Systems, Inc., Toronto, Ontario) and J. J. GOTTLIEB Mar. 1990 45 p
(UTIAS-335; ISSN-0082-5255) Copyright Avail: Issuing Activity

Work on the development of an efficient and accurate computer code for the prediction of hypersonic flows within model hypersonic inlets is reported, and numerical results for some test problems are presented. The finite difference technique and total variation diminishing (TVD) scheme are summarized with Roe's approximate Riemann solver, which are incorporated into the code, in order to predict nonstationary planar and axisymmetric flows with steep shocks and thin slip streams on 2-D grids having multiple connected domains. Author

N90-25936# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
FLIGHT TESTING OF A NATURAL LAMINAR FLOW AIRFOIL USING GLIDERS
P. RAMAMOORTHY Mar. 1990 11 p
(Contract NAL PROJ. FM-8-208)
(PD-CF-9005) Avail: NTIS HC A03/MF A01

A proposed flight test program to conduct pressure measurements and flow visualization on Natural Laminar Flow (NLF) airfoils using gliders is described. Author

N90-25937# Wichita State Univ., KS. National Inst. for Aviation Research.
PREDICTION METHODOLOGIES FOR NONLINEAR AERODYNAMIC CHARACTERISTICS OF CONTROL SURFACES M.S. Thesis
BRIAN P. LEE Jun. 1990 201 p
(NIAR-90-17) Avail: NTIS HC A10/MF A02

As airplane performance demands increase it will be necessary to understand and make use of aerodynamic characteristics well into the nonlinear operating range. There is a large body of parametric test data available which addresses a variety of significant features and their aerodynamic consequences. Historically, a number of efforts have been mounted to assimilate this data and reduce it to a form useful for design. Three of these are examined in light of their principal independent variable sets and their ability to model a variety of specific configurations. It is postulated that inadequacies in previous attempts to generalize this data resulted from both the linear model formulation and the lack of sufficient computing power to permit more sophisticated techniques. Recent advances in computing power and data reduction methods now provide the ability to address very large nonlinear multi-dimensional problems in a timely manner. The ability of one of these methods to digest a large subset of the test data and extract salient features in model form is demonstrated. The resulting model demonstrates sensitivity to fundamentally significant independent variables, and produces significant improvements in fidelity at off-zero incidence and control deflections, yet retains a form which is readily linearized about a given condition for use in small perturbation stability analysis. The nonlinear model form is also shown to provide significantly more insight into off design characteristics than previous linear formulations. Author

N90-25938*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECT OF TAIL SIZE REDUCTIONS ON LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF A THREE SURFACE F-15 MODEL WITH NONAXISYMMETRIC NOZZLES
MARK C. FRASSINELLI (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.) and GEORGE T. CARSON, JR. Washington Aug. 1990 59 p
(NASA-TP-3036; L-16800; NAS 1.60:3036) Avail: NTIS HC A04/MF A01 CSCL 01/1

An investigation was conducted in the Langley 16-Foot Transonic Tunnel to determine the effects of horizontal and vertical tail size reductions on the longitudinal aerodynamic characteristics of a modified F-15 model with canards and 2-D convergent-divergent nozzles. Quantifying the drag decrease at low angles of attack produced by tail size reductions was the primary focus. The model was tested at Mach numbers of 0.40, 0.90, and 1.20 over an angle of attack of -2 degree to 10 degree. The nozzle exhaust flow was simulated using high pressure air at nozzle pressure ratios varying from 1.0 (jet off) to 7.5. Data were obtained on the baseline configuration with and without tails as well as with reduced horizontal and/or vertical tail sizes that were 75, 50, and 25 percent of the baseline tail areas. Author

N90-25939*# Vigyan Research Associates, Inc., Hampton, VA.
EFFECTS OF FOREBODY GEOMETRY ON SUBSONIC BOUNDARY-LAYER STABILITY
SIMHA S. DODBELE Washington NASA Aug. 1990 20 p
Presented at the 5th International Conference on Numerical Methods in Laminar and Turbulent Flow, Montreal, Quebec, 6-10 Jul. 1987 Previously announced in IAA as A88-30509
(Contract NAS1-17919)
(NASA-CR-4314; NAS 1.26:4314) Avail: NTIS HC A03/MF A01 CSCL 01/1

As part of an effort to develop computational techniques for design of natural laminar flow fuselages, a computational study was made of the effect of forebody geometry on laminar boundary layer stability on axisymmetric body shapes. The effects of nose radius on the stability of the incompressible laminar boundary layer was computationally investigated using linear stability theory for body length Reynolds numbers representative of small and medium-sized airplanes. The steepness of the pressure gradient and the value of the minimum pressure (both functions of fineness ratio) govern the stability of laminar flow possible on an axisymmetric body at a given Reynolds number. It was found that to keep the laminar boundary layer stable for extended lengths, it is important to have a small nose radius. However, nose shapes with extremely small nose radii produce large pressure peaks at off-design angles of attack and can produce vortices which would adversely affect transition. Author

N90-25940*# Purdue Univ., West Lafayette, IN.
AN UNSTEADY LIFTING SURFACE METHOD FOR SINGLE ROTATION PROPELLERS Final Report
MARC H. WILLIAMS Washington NASA Jul. 1990 62 p
(Contract NAG3-499)
(NASA-CR-4302; E-5428; NAS 1.26:4302) Avail: NTIS HC A04/MF A01 CSCL 01/1

The mathematical formulation of a lifting surface method for evaluating the steady and unsteady loads induced on single rotation propellers by blade vibration and inflow distortion is described. The scheme is based on 3-D linearized compressible aerodynamics and presumes that all disturbances are simple harmonic in time. This approximation leads to a direct linear integral relation between the normal velocity on the blade (which is determined from the blade geometry and motion) and the distribution of pressure difference across the blade. This linear relation is discretized by breaking the blade up into subareas (panels) on which the pressure difference is treated as approximately constant, and constraining the normal velocity at one (control) point on each panel. The piece-wise constant loads can then be determined by Gaussian elimination. The resulting blade loads can be used in performance, stability and forced response predictions for the rotor. Mathematical and numerical aspects of the method are examined. A selection of results obtained from the method is presented. The appendices include various details of the derivation that were felt to be secondary to the main development in Section 1. Author

N90-25941# Sandia National Labs., Albuquerque, NM.
WIND TUNNEL STUDY OF WAKE DOWNWASH BEHIND A 6 PERCENT SCALE MODEL B1-B AIRCRAFT
JAMES H. STRICKLAND, EDEN L. TADIOS, and DAVID A. POWERS May 1990 86 p
(Contract DE-AC04-76DP-00789)
(DE90-011783; SAND-90-0008) Avail: NTIS HC A05/MF A01

Parachute system performance issues such a turnover and wake recontact may be strongly influenced by velocities induced by the wake of the delivering aircraft, especially if the aircraft is maneuvering at the time of parachute deployment. The effect of the aircraft on the parachute system is a function of the aircraft size, weight, and flight path. In order to provide experimental data for validation of a computer code to predict aircraft wake velocities, a test was conducted in the NASA 14 by 22 ft wind tunnel using a 5.78 percent model of the B-1B strategic bomber. The model was strut mounted through the top of its fuselage by a mechanism which was capable of pitching the model at moderate rates. In this series of tests, the aircraft was pitched at 10 deg/sec from a cruise angle of attack of 5.3 deg to an angle of attack of 11 deg in order to simulate a 2.2g pullup. Data were also taken for the subsequent pitch down sequence back to the cruise angle of attack. Instantaneous streamwise and vertical velocities were measured in the wake at a number of points using a hot wire anemometer. These data were reduced to the form of downwash coefficients which are a function of the aircraft angle of attack time history. Unsteady effects are accounted for by use of a wake convection lag-time correlation. DOE

N90-25942# Institut Franco-Allemand de Recherches, Saint-Louis (France).
AERODYNAMIC LOADS AND BLADE VORTEX INTERACTION NOISE PREDICTION
M. SCHAFFAR, J. HAERTING, and P. GNEMMI 1989 16 p Presented at 15th European Rotorcraft Forum, Amsterdam, Netherlands, 12-15 Sep. 1989
(ISL-PU-310/89; ETN-90-97024) Avail: NTIS HC A03/MF A01

The vortex lattice method is described and applied in order to predict the aerodynamic loads on a thin two-bladed rotor. A local conformal mapping for each position in span is used to transform the thin rotor into a thick one. The pressure coefficients obtained for the thick rotor are fed into an acoustic code which is based on the Ffowcs-Williams-Hawkings equation. The results obtained with this method show the importance of the rotor and flight parameters; they are compared with results found in the literature for a two-bladed rotor in hovering and advancing. The comparison shows a good agreement and shows that the cut-off length for limiting the instabilities from the Biot and Savart law must be chosen carefully. ESA

N90-25943*# Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.
IDENTIFICATION OF AERODYNAMIC MODELS FOR MANEUVERING AIRCRAFT Semiannual Status Report
SUEI CHIN and C. EDWARD LAN Aug. 1990 51 p
(Contract NAG1-1087)
(NASA-CR-186630; NAS 1.26:186630; KU-FRL-872-1) Avail: NTIS HC A04/MF A01 CSCL 01/1

Due to the requirement of increased performance and maneuverability, the flight envelope of a modern fighter is frequently extended to the high angle-of-attack regime. Vehicles maneuvering in this regime are subjected to nonlinear aerodynamic loads. The nonlinearities are due mainly to three-dimensional separated flow and concentrated vortex flow that occur at large angles of attack. Accurate prediction of these nonlinear airloads is of great importance in the analysis of a vehicle's flight motion and in the design of its flight control system. A satisfactory evaluation of the performance envelope of the aircraft may require a large number of coupled computations, one for each change in initial conditions. To avoid the disadvantage of solving the coupled flow-field equations and aircraft's motion equations, an alternate approach is to use a mathematical modeling to describe the steady and unsteady aerodynamics for the aircraft equations of motion. Aerodynamic forces and moments acting on a rapidly maneuvering aircraft are, in general, nonlinear functions of motion variables, their time rate of change, and the history of maneuvering. A numerical method was developed to analyze the nonlinear and time-dependent aerodynamic response to establish the generalized indicial function in terms of motion variables and their time rates of change. Author

N90-25944*# Boeing Commercial Airplane Co., Seattle, WA.
APPLICATION OF LAMINAR FLOW CONTROL TO SUPERSONIC TRANSPORT CONFIGURATIONS Final Report, Oct. 1987 - Dec. 1988
P. G. PARIKH and A. L. NAGEL Jul. 1990 191 p
(Contract NAS1-15325)
(NASA-CR-181917; NAS 1.26:181917) Avail: NTIS HC A09/MF A01 CSCL 01/1

The feasibility and impact of implementing a laminar flow control system on a supersonic transport configuration were investigated. A hybrid laminar flow control scheme consisting of suction controlled and natural laminar flow was developed for a double-delta type wing planform. The required suction flow rates were determined from boundary layer stability analyses using representative wing pressure distributions. A preliminary design of structural modifications needed to accommodate suction through a perforated titanium skin was carried out together with the ducting and systems needed to collect, compress and discharge the suction air. The benefits of reduced aerodynamic drag were weighed against the weight, volume and power requirement penalties of suction system installation in a mission performance and sizing

program to assess the net benefits. The study showed a feasibility of achieving significant laminarization of the wing surface by use of a hybrid scheme, leading to an 8.2 percent reduction in the cruise drag. This resulted in an 8.5 percent reduction in the maximum takeoff weight and a 12 percent reduction in the fuel burn after the inclusion of the LFC system installation penalties. Several research needs were identified for a resolution of aerodynamics, structural and systems issues before these potential benefits could be realized in a practical system. Author

N90-25945*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A BRIEF REVIEW OF SOME MECHANISMS CAUSING BOUNDARY LAYER TRANSITION AT HIGH SPEEDS
M. E. TAUBER Jun. 1990 12 p
(NASA-TM-102834; A-90186; NAS 1.15:102834) Avail: NTIS HC A03/MF A01 CSCL 01/1

In high speed flight, the state of the boundary layer can strongly influence the design of vehicles through its effect on skin friction drag and aerodynamic heating. The major mechanisms causing boundary layer transition on high speed vehicles are briefly reviewed and some empirical relations from the unclassified literature are given for the transition Reynolds numbers. Author

N90-25946*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EULER ANALYSIS COMPARISON WITH LDV DATA FOR AN ADVANCED COUNTER-ROTATION PROPFAN AT CRUISE
CHRISTOPHER J. MILLER and GARY G. PODBOY Aug. 1990 23 p Presented at the 8th Applied Aerodynamics Conference, Portland, OR, 20-22 Aug. 1990; sponsored in part by AIAA
(NASA-TM-103249; E-5676; NAS 1.15:103249; AIAA-90-0438) Avail: NTIS HC A03/MF A01 CSCL 01/1

A fine mesh Euler solution of the F4/A4 unducted fan (UDF) model flowfield is compared with laser Doppler velocimeter (LDV) data taken in the NASA Lewis 8- by 6-Foot Supersonic Wind Tunnel. The comparison is made primarily at one axial plane downstream of the front rotor where the LDV particle lag errors are reduced. The agreement between measured and predicted velocities in this axial plane is good. The results show that a dense mesh is needed in the centerbody stagnation region to minimize entropy generation that weakens the aft row passage shock. The predicted radial location of the tip vortex downstream of the front rotor agrees well with the experimental results but the strength is overpredicted. With 40 points per chord line, the integrated performance quantities are nearly converged, but more points are needed to resolve passage shocks and flow field details. Author

N90-25947# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
TECHNICAL EVALUATION REPORT ON THE FLUID DYNAMICS PANEL SYMPOSIUM ON COMPUTATIONAL METHODS FOR AERODYNAMIC DESIGN (INVERSE) AND OPTIMIZATION
PRESTON A. HENNE and J. W. SLOOFF, ed. (National Aerospace Lab., Amsterdam, Netherlands) Apr. 1990 16 p Symposium held in Loen, Norway, 22-23 May 1989
(AGARD-AR-267; ISBN-92-835-0557-3) Copyright Avail: NTIS HC A03/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The papers presented at the symposium are reviewed as a whole. Strengths and weaknesses are identified for many of the contributions as each is reviewed. The reviewer closes with some general comments. The 23 papers presented at the Meeting have been collected in AGARD-CP-463. Author

N90-25948*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TWO-DIMENSIONAL EULER AND NAVIER-STOKES TIME ACCURATE SIMULATIONS OF FAN ROTOR FLOWS
A. A. BORETTI (Fiat Research Center, Orbassano, Turin, Italy) Jul. 1990 22 p
(Contract NASA ORDER C-99066-G)
(NASA-TM-102402; E-5155; NAS 1.15:102402; ICOMP-89-29)
Avail: NTIS HC A03/MF A01 CSCL 01/1

Two numerical methods are presented which describe the unsteady flow field in the blade-to-blade plane of an axial fan rotor. These methods solve the compressible, time-dependent, Euler and the compressible, turbulent, time-dependent, Navier-Stokes conservation equations for mass, momentum, and energy. The Navier-Stokes equations are written in Favre-averaged form and are closed with an approximate two-equation turbulence model with low Reynolds number and compressibility effects included. The unsteady aerodynamic component is obtained by superposing inflow or outflow unsteadiness to the steady conditions through time-dependent boundary conditions. The integration in space is performed by using a finite volume scheme, and the integration in time is performed by using k-stage Runge-Kutta schemes, k = 2,5. The numerical integration algorithm allows the reduction of the computational cost of an unsteady simulation involving high frequency disturbances in both CPU time and memory requirements. Less than 200 sec of CPU time are required to advance the Euler equations in a computational grid made up of about 2000 grid during 10,000 time steps on a CRAY Y-MP computer, with a required memory of less than 0.3 megawords. Author

N90-25949# National Aerospace Lab., Tokyo (Japan).
SPACE PLANE MODEL FOR VISUAL MEASUREMENT OF AERODYNAMIC HEATING
MITUNORI WATANABE Aug. 1989 21 p In JAPANESE
(DE90-505514; NAL-TM-608; ISSN-0452-2982) Avail: NTIS (US Sales Only) HC A03/MF A01

Space plane models (300 mm in length) were fabricated with electroformed molds. High heat resistant epoxy resin (STYCAST) was used for a model material, and the glossy models superior in heat resistance, heat insulation and rigidity were obtained, as well as a prospect for low cost production of several models with the same accuracy. While errors of the model were + or - 1 percent in thickness of a fuselage and -0.3 mm in mean thickness of a main wing, errors due to the mold were -1 percent and -0.1 mm, respectively. The mold error was mainly dependent on the machining accuracy of a positive mold, and thermal deformation in a burning process for molding. A three-dimensional instrument and numerical control machine tool had the potential of enhancing the machining accuracy considerably. On the other hand, a split mold with a back stiffening plate and the use of smaller amounts of mold releasing agent had the potential of reducing thermal deformation. DOE

N90-25950# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
EXPERIMENTAL STUDY ON VORTEX AND SHOCK WAVE DEVELOPMENT ON A 65 DEG DELTA WING
A. ELSENAAR and K. A. BUETEFISCH 20 May 1988 14 p Presented at IUTAM Symposium Transsonicum 3, Goettingen, Fed. Republic of Germany, 24-27 May 1988
(NLR-MP-88033-U; ETN-90-97186) Avail: NTIS HC A03/MF A01

The analysis of the transonic flow over a 65 degrees delta wing at Mach equal to 0.85 is presented. Pressure data, flow visualizations and laser Doppler anemometry flow field measurements are used. It is argued that shock waves and shock induced separations can induce primary and secondary vortices. Near the symmetry plane another shock is observed that seems to interact in a very abrupt way with vortex break down. ESA

N90-25951# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
COMPUTATION OF VISCOUS AERODYNAMIC CHARACTERISTICS OF 2-D AIRFOILS FOR HELICOPTER APPLICATIONS
R. HOUWINK, J. A. VANEGMOND, and P. A. VANGELDER 9 Jan. 1988 19 p Presented at 14th European Rotorcraft Forum, Milan, Italy, 20-23 Sep. 1988
(NLR-MP-88052-U; ETN-90-97189) Avail: NTIS HC A03/MF A01

A computer code, used for the prediction of quasi-steady and unsteady aerodynamic characteristics of rotor blade section in oscillatory and linear pitching motions is presented. The code, named ULTRAN-5, is based on unsteady transonic small perturbation theory, coupled in strong interaction with an unsteady version of Green's lag-entrainment method for a turbulent boundary layer. Results are compared with experimental data for the NACA0012 airfoil and for actual rotor blade sections. Provided that the stall behavior is not dominated by leading edge separation, an accurate prediction of quasi-steady and unsteady airfoil characteristics up to stall conditions is obtained. ESA

N90-25953# Royal Aerospace Establishment, Farnborough (England).
FORMATION OF DESIGN ENVELOPE CRITERION IN TERMS OF DETERMINISTIC SPECTRAL PROCEDURE
J. G. JONES 17 Jan. 1990 15 p
(RAE-TM-SS-9; BR113195; ETN-90-97066) Copyright Avail: NTIS HC A03/MF A01

An existing design envelope approach to meeting aircraft limit load requirements for flight in continuous turbulence, using power spectral methods, is reformulated in a manner which makes no distinction between linear and non-linear aircraft response. Computational techniques for implementing the new procedure in applications to nonlinear aircraft are discussed and compared with existing simulation methods. ESA

N90-25954*# Eloret Corp., Palo Alto, CA.
EXPERIMENTAL AEROTHERMODYNAMIC RESEARCH OF HYPERSONIC AIRCRAFT Final Technical Report, 1 Mar. 1986 - 31 Jul. 1990
JOSEPH W. CLEARY 23 Aug. 1990 17 p
(Contract NCC2-416)
(NASA-CR-186903; NAS 1.26:186903) Avail: NTIS HC A03/MF A01 CSCL 01/1

Wind tunnel tests were conducted to establish a benchmark experimental data base for a genetic hypersonic aircraft vehicle. Comprehensive measurements were made at Mach 7 to give flow visualization, surface pressure, surface convective heat transfer, and flow field Pitot pressure for a delta platform all-body vehicle. The tests were conducted in the NASA/Ames 3.5-Foot Hypersonic Wind Tunnel at Reynolds numbers sufficient to give turbulent flow. Comparisons are made of the experimental results with computational solutions of the flow by an upwind parabolized Navier-Stokes code developed at Ames. Good agreement of experiment with solutions by the code is demonstrated. Author

N90-25955# Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Technology Div.
EFFECT OF VORTEX GENERATORS ON THE AERODYNAMIC WING CHARACTERISTICS AND BODY OF REVOLUTION
A. M. MKHITARYAN, S. A. LUKASHUK, V. D. TRUBENOK, and V. YA. FRIDLAND 3 May 1990 24 p Transl. into ENGLISH from Gidroaerodinamika Nesushchikh Poverkhnostey (Kiev, USSR, Naukova Dumka), 1966 p 254-263
(AD-A222813; FTD-ID(RS)T-0266-90) Avail: NTIS HC A03/MF A01 CSCL 01/1

The results are presented of experimental investigations of the effect of vortex generators on the aerodynamic characteristics of streamlined bodies. Qualitative results are obtained corrobating the possibility of stabilizing the intact flow over a wing at large angles of attack. The results of an experiment on the flow over bodies of revolution with vortex generators are presented. GRA

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A90-42648
THE PLANNING OF AIR TRANSPORTATION ON AIRLINES [PLANIROVANIE DVIZHENIIA SAMOLETOV NA VOZDUSHNYKH LINIIAKH]
ALEKSANDR N. SUBBOTIN, VLADIMIR I. BOIKO, and EVGENII M. MOLOCHKOV Kiev, Izdatel'stvo Tekhnika, 1989, 200 p. In Russian. refs
Copyright

Methodology for the planning of air transportation on the regional level is presented. The approach involves the formation of the optimal structure and topology of airlines, taking into account the demand level on passenger transportation and its seasonal changess, as well as the level of air traffic. The goal is to make effective use of the aircraft fleet and the material and engineering resources of aviation companies. The reliability optimization of planning indices is considered, and a procedure for the effective distribution of material resources among regional aviation companies is presented. B.J.

A90-44222
PROMPT IDENTIFICATION OF A TROUBLED ENGINE CAN HELP AVOID CATASTROPHE
ROBERT N. BUCK ICAO Journal (ISSN 0018-8778), vol. 45, Feb. 1990, p. 22, 23.
Copyright

Low thrust detection systems (LTDS) can aid in detection of failed engines allowing for more rapid analysis and prompt action. Warning lights are used to indicate which engine has failed. These lights are mounted on propeller pitch controls and activated if power from an engine drops below 50 percent. An aural warning is activated when power is lost. A separate set of warning lights, accompanied by a beep, indicates a power loss of 15 percent to under 50 percent. This pneumo-electrical system consists of a total-pressure sensor mounted on each engine aft of the propeller where it is impacted by the air stream behind the propeller. The total air pressure flows to a sensor that compares the thrust of one engine with that of the other; a control unit translates the pressure into electrical pulses to the indicators in the event of a significant thrust drop in one engine. L.K.S.

A90-44548
MORE CRUISING LEVELS EXPECTED AT HIGHER ALTITUDES
MARINUS C. F. HEIJL (International Civil Aviation Organization, Air Navigation Bureau, Montreal, Canada) ICAO Journal (ISSN 0018-8778), vol. 45, Jan. 1990, p. 11-13.
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The question of a reduction in vertical separation minima (VSM) is raised and the results of a feasibility study are discussed. In this study, data were collected and a collision-risk assessment was made using the collision-risk modeling/target level of safety methodology. Based on collision-risk assessment, the ICAO Air Navigation Commission's Review of the General Concept of Separation Panel concluded in late 1988 that global application of a 300-m VSM between flight level (FL) 290 and FL 410 was feasible in the longer term, subject to the introduction of a global altimetry specification to improve aircraft height-keeping capacity, new operating procedures, and system performance monitoring. In the interim period, implementation of a reduced VSM was considered feasible on a regional basis, as risk estimates were found to be higher for European and United States continental airspace. L.K.S.

A90-44550
EFFORTS CONTINUE TO INCREASE AIRPORT/AIRSPACE CAPACITY
GIORA NAGID (International Civil Aviation Organization, Air Navigation Bureau, Montreal, Canada) ICAO Journal (ISSN 0018-8778), vol. 45, Jan. 1990, p. 21-24.
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Efforts are under way to increase air transport capacity by reducing the separation distance between parallel runways used simultaneously under instrument flight rule operations. Demonstration projects using new precision runway monitor (PRM) sensors and spacing reduction between parallel runway center lines are discussed. Different systems are under observation. The PRM at Memphis airport, in test operation since 1988, uses a back-to-back antenna, allowing it to update aircraft position every 2.4 seconds while the PRM at Raleigh-Durham airport employs an electrically scanned antenna which allows target update every 0.5 seconds. This is nearly a tenfold improvement over current terminal surveillance radars. A number of test scenarios are to be staged, at first by computer simulator, and later by manned craft. A recommendation is presented, listing minimum separation distances between center-lines of parallel runways which are provided for simultaneous operation under instrument meteorological conditions. L.K.S.

A90-44640
A COMPARISON OF EMERGENCY MEDICAL HELICOPTER ACCIDENT RATES IN THE UNITED STATES AND THE FEDERAL REPUBLIC OF GERMANY
KENNETH J. RHEE, EDWARD M. HOLMES, III, HEINZPETER P. MOECKE, and FRANK O. THOMAS (California State University, Sacramento) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 61, Aug. 1990, p. 750-752. Research supported by Aerospatiale Helicopter Corp. refs
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The purpose of this study was to compare accident rates of helicopter emergency medical services (USA-HEMS) to domesstic air taxi service (USA-Taxi) and helicopter emergency medical services in the FRG (FRG-HEMS). Contingency tables compared the total hours flown to the number of fatal and nonfatal accidents for USA-HEMS (1982-1987) vs USA-Taxi (1980-1985) and USA-HEMS (1982-1987) vs FRG-HEMS (1982-1987). The overall accident rate for USA-HEMS was 11.7/100,000 h, with the fatal accident rate being 4.7/100,000 h. This was significantly different from the USA-Taxi overall accident rate of 6.7/100,000 h and the fatal accident rate of 1.6/100,000 h (chi sq = 20.441, p = 0.0001). The USA-HEMS overall and fatal accident rates were not significantly different than the FRG-HEMS overall (10.9/100,000 h) and fatal (4.1/100,000 h) accident rate (chi sq = 0.061, p = 0.97). These data suggest that emergency air transport is inherently more risky than routine air taxi services. Author

A90-44656
ESCAPE SYSTEM EVOLUTION
PERRY NELSON (USAF, San Antonio Air Logistics Center, Kelly AFB, TX) Aeromedical and Training Digest (ISSN 0001-9275), vol. 4, Jan. 1990, p. 23-25.
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The evolution of escape systems in military aircraft is traced and it is pointed out that advances in aviation technology have dictated the need for a fast and fully automated escape system. Successive technological advances of such a system are outlined, including developments in areas such as seat stability, quicker operating times, improved reliability, and maintenance down-time. The structure, subsystems technology, and electronically controlled sequencing of the USAF Advance Concept Ejection Seat (ACES II) is treated in detail. It is noted that the ACES II is configured for optimum performance throughout the 0 to 600 knot escape envelope and uses solid-state redundant timing circuits in conjunction with electronically activated ballistic components to ensure proper timing and sequencing for each component in each of three available recovery modes. Subsystems include speed and altitude sensing components, a pitch control stabilization rocket, and a unique parachute recovery system. L.K.S.

A90-44658
ESCAPE AND SURVIVAL FOLLOWING HELICOPTER DITCHING - TRAINING ASPECTS
P. J. SOWOOD (RAF, Institute of Aviation Medicine, Farnborough, England) Aeromedical and Training Digest (ISSN 0001-9275), vol. 4, Jan. 1990, p. 31-33.
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Reported findings from the Naval Safety Center in Norfolk, Virginia show that, of those individuals who had undergone dunker training with simulated underwater escape conditions, eight percent involved in helicopter ditchings died in contrast to 20 percent who did not undergo training. Training schemes and limitations of dunker training, such as absence of cold or turbid water, are discussed. Recent developments in underwater escape aids are cited such as exit lights, illuminated guide bars, exit release mechanisms, and underwater breathing devices. New ideas for training are outlined, including more frequent and/or longer dunker training facilitated by a less expensive way for personnel to achieve this training. A less stressful underwater escape experience for beginners is recommended in order to help increase confidence and therefore boost effectiveness in executing learned escape manuevers during the instruction process. L.K.S.

A90-44659
ESCAPE AND SURVIVAL FOLLOWING HELICOPTER DITCHING - RESEARCH ASPECTS
J. RICHARD ALLAN (RAF, Institute of Aviation Medicine, Farnborough, England) Aeromedical and Training Digest (ISSN 0001-9275), vol. 4, Jan. 1990, p. 33-35. refs
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Development of improved escape aids in the form of hatch lighting, route guidance systems, underwater breathing systems, and improved design of escape hatches and their release facilities for use in conditions of extreme cold and low visibility due to high water turbidity is discussed. New developments in these areas include compact underwater breathing systems which can be man-mounted and provide from 40 seconds to two minutes of critical breathing during escape, simplified escape hatch release mechanisms, and revised hatch size requirements for easier and more rapid exit. A recent survey of United Kingdom military helicopter ditchings indicates that approximately 50 percent of the fatalities might be avoided by improved escape aids such as these. L.K.S.

A90-44662
TOXICOLOGY IN AVIATION
ALLEN J. PARMET (USAF, Brooks AFB, TX) Aeromedical and Training Digest (ISSN 0001-9275), vol. 4, Jan. 1990, p. 43-47. refs
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Potential toxic agents involved in the construction, maintenance, and operation of aircraft are reviewed. During the manufacturing process of aircraft, cutting oils used in the metal fabrication of aircraft as well as polytetrafluoroethylene and polyurethane paints pose potential health hazards. Chemicals involved in interior installation of electrical components, wiring, tubing and installation are also cited as potentially dangerous. Health problems posed by composite materials are explored. Improper exposure to petroleum-based fuels and solvents associated with aviation gasoline and jet fuel, hydraulic fluid, greases, deicer solutions, and cleaning fluids are cited as potential hazardous materials involved in the maintenance process and may cause skin problems, depression or injury of the central nervous system, or carcinogenesis. Accidental exposure to toxic agents is also discussed, including exposure during otherwise normal aircrew operations and exposure due to aircraft mishaps or accidents. L.K.S.

A90-45445
THE COMMON/SAME TYPE RATING - HUMAN FACTORS AND OTHER ISSUES
ROLF BRAUNE (Boeing Commercial Airplanes, Seattle, WA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 7 p. refs
(SAE PAPER 892229) Copyright

The concepts of the Common and Same Type Rating are undoubtedly very attractive in today's cost-conscious airline operating environment. They allow the airlines to reduce their training and piloting costs while at the same time increasing scheduling flexibility by conducting mixed-fleet operations. However, certain types of flight deck differences beyond appropriate boundaries can result in increased workload and reduced crew performance. In addition, the introduction of advanced technologies, including those which enhance safety, can be delayed. This paper will attempt to shed some light on this complex issue by first defining what the Common/Same Type Rating is, by reviewing some of the experiences reported so far in mixed-fleet operations, and it will then discuss what some of the underlying human factors issues are and how known guidelines could be applied to future designs. The paper will conclude by trying to focus the industry's attention, (i.e., airplane manufacturers, airlines, and government agencies) on those areas in design, training, and scheduling where additional data is desperately needed. Author

A90-45468
EFFECTS OF STAGE 3 RULES ON THE AIRLINER MARKET
JOHN A. CASEY (Avmark, Inc., Arlington, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 12 p.
(SAE PAPER 892292) Copyright

New noise regulations are coming in North American and Europe. They will affect airliners which do not meet the latest noise standards - more than 60 percent of the present passenger fleet around the world - and could create a crisis in capacity and the ability to finance modification or replacement. Much depends on the attitudes of the Federal Aviation Administration and the European Community, which must decide when to impose new standards and which must face the economic and transportation problems raised by that decision. Author

N90-25089# Messerschmitt-Boelkow-Blohm G.m.b.H., Hamburg (Germany, F.R.). Unternehmensgruppe Transport- und Verkehrsflugzeuge.
SIMULATION OF TRANSPORT AEROPLANES [SIMULATION VON TRANSPORTFLUGZEUGEN]
ROBERT LUCKNER *In its* Research and Development: Technical and Scientific Publications 1989 p 115-122 1989 In GERMAN Presented at ASIM-Arbeitskreis-Treffen Simulation Technischer Systeme, Stuttgart, Fed. Republic of Germany, 2-3 Mar. 1989
(MBB-UT-007/89-PUB) Avail: NTIS HC A15/MF A02

A realtime development simulator is described. It is made of three simulation computers, a simulation software, a cockpit with sight simulation, noise system, interfaces and reading and service unities, and test plants with avionic testbench, avionic signal conversion and test computer, test control computer, test registration and analysis computer. Other devices are tested, such as flight augmentation computer, center of gravity control system, flutter margin augmentation system, fly-by-wire computer, hydraulic actuator. The calculation programs simulate physical properties by mathematical models, such as elastic structure of the plane, aerodynamic forces and moments and inertia moments. The simulations made on the Airbus planes are shown to be successful. ESA

N90-25103# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.). Unternehmensgruppe Hubschrauber und Flugzeuge.
DEVELOPMENT AND TEST OF SOFTWARE BY SAFETY CRITICAL AIRCRAFT SYSTEMS [ENTWICKLUNG UND PRUEFUNG VON SOFTWARE BEI SICHERHEITSKRITISCHEN LUFTFAHRTSYSTEMEN]
In its Research and Development: Technical and Scientific Publications 1989 p 319-324 1989 In GERMAN Presented at Fachseminar Sicherheitstechnik am Beispiel des Schienenverkehrs; Entwicklung ins naechste Jahrtausend, Brunswick, Fed. Republic of Germany, 18-19 Oct. 1988
(MBB-FE-363/S/PUB-384) Avail: NTIS HC A15/MF A02

A software validation and checkout methodology is presented. An aeroplane needs onboard calculator systems for navigation, communication, generation of control signals and system supervision. The software demands some characteristics, such as safety critical point, distributed processing, fast realtime processing, embedded systems, man-machine communication. The security aspects are achieved by software requirements hazard analysis, top level design hazard analysis, detailed design hazard analysis, code level software analysis, software safety testing and software/user interfaces analysis. ESA

N90-25117# General Engineering and Systems Analysis Co., Inc., Silver Spring, MD.
DEVELOPMENT OF A MICROCOMPUTER BASED SOFTWARE SYSTEM FOR USE IN CREWMEMBER EJECTION ANALYSIS Final Report, Feb. - Aug. 1989
NAGARAJAN RANGARAJAN 18 Aug. 1989 10 p
(Contract F33615-88-C-0544; AF PROJ. 7231)
(AD-A220398; AAMRL-SR-89-501) Avail: NTIS HC A02/MF A01 CSCL 12/5

A prototype of DYNAMAN, which is an implementation of the Articulated Total Body (ATB) Model on PCs, was developed. DYNAMAN is an interactive software which can be used to analyze the dynamics of vehicle occupants and crewmember ejection problems. It is menu driven and is comprised of the preprocessor, the simulation module and the postprocessor. DYNAMAN will run on Intel 80286 based machines with appropriate math coprocessors. The preprocessor allows the analyst to set up, interactively, the input data set for the simulation module. The simulation module accepts input data sets created by the preprocessor and standard ATB-IV.O input data sets and produces picture, plot and print output files. The simulation module also calculates common injury measures such as the Chest Severity Index (CSI), Head Severity Index (HSI), and Head Injury Criteria (HIC). The postprocessor can be used to examine the motion of the vehicle occupant, and to obtain plots of various dynamic variables or to view them as tables. GRA

N90-25118 Department of the Navy, Washington, DC.
YAW FIN DEPLOYMENT APPARATUS FOR EJECTION SEAT Patent
ANTHONY T. TRAN, inventor (to Navy), CHI R. TUNG, inventor (to Navy), and PETER W. YOST, inventor (to Navy) 20 Feb. 1990 7 p Filed 5 Jul. 1988 Supersedes AD-D014148
(AD-D014512; US-PATENT-4,901,951;
US-PATENT-APPL-SN-215139; US-PATENT-CLASS-244-122)
Avail: US Patent and Trademark Office CSCL 01/3

A yaw fin deployment apparatus provides a continuous deployment force to the fin during the entire range of deployment. A shaft, a movable sleeve bearing for riding along the shaft, a strut connected between the sleeve bearing and the fin, and a lanyard for continuously pulling the sleeve bearing along the shaft are provided. The momentum created when the ejection seat separates from the aircraft is transmitted to the lanyard, to the sleeve bearing, and to the strut for deploying the fin. A pulley is attached to the seat and is located near the aft end of the shaft and guides the lanyard to assure that the actuation force exerted on the sleeve bearing is in a direction parallel to the axis of the shaft. When the fin is fully deployed, the lanyard separates from the sleeve bearing through a split ring at the bottom of the sleeve bearing. A primary spring-loaded latch located at the aft end of the shaft locks the fin in a fully deployed position. GRA

N90-25119# Dayton Univ., OH.
STUDY OF THE ENGINE BIRD INGESTION EXPERIENCE OF THE BOEING 737 AIRCRAFT (OCTOBER 1986 TO SEPTEMBER 1988) Interim Report

PETER HOVEY and DONALD A. SKINN May 1990 148 p Prepared in cooperation with Federal Aviation Administration, Atlantic City, NJ
(Contract DTFA03-88-C-00024)
(DOT/FAA/CT-89/29; UDR-TR-89-65) Avail: NTIS HC A07/MF A01

The Federal Aviation Administration (FAA) Technical Center initiated a study in October 1986 to determine the numbers, sizes, and types of birds which are being ingested into medium and large inlet area turbofan engines and to determine what damage, if any, results. Bird ingestion data are being collected for the Boeing 737 model aircraft which uses either the Pratt and Whitney JT8D medium inlet area turbofan engine or the CFM International CFM56 large inlet area turbofan engine. The first 2 years of data collection for the 3-year study are analyzed. Author

N90-25120*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
VIDEO PHOTOGRAPHIC CONSIDERATIONS FOR MEASURING THE PROXIMITY OF A PROBE AIRCRAFT WITH A SMOKE SEEDED TRAILING VORTEX
BROOKS A. CHILDERS and WALTER L. SNOW Jun. 1990 24 p
(NASA-TM-102691; NAS 1.15:102691) Avail: NTIS HC A03/MF A01 CSCL 01/3

Considerations for acquiring and analyzing 30 Hz video frames from charge coupled device (CCD) cameras mounted in the wing tips of a Beech T-34 aircraft are described. Particular attention is given to the characterization and correction of optical distortions inherent in the data. Author

N90-25956# Wichita State Univ., KS. Inst. for Aviation Research.
COMPUTATIONAL CRASH DYNAMICS. PROJECT 1.2: COMPUTATIONAL CRASH DYNAMICS ANALYSIS Final Report
WALTER J. HORN and DAN L. CHRISTMORE Oct. 1989 75 p
(Contract DTFA03-96-C-00041)
(IAR-89-19) Avail: NTIS HC A04/MF A01

The purpose of this research effort was to develop an analytical capability to predict the crashworthiness characteristics of composite aircraft. A literature survey of crashworthiness research work indicated that the computer code, KRASH, was probably the best suited for information. The code is a hybrid and thus requires a great deal of input data that is typically generated by structural tests. In an effort to make this code useful at the preliminary design stage, modifications were investigated which could be incorporated into KRASH so that the crashworthiness of the vehicle could be evaluated without the requirement for structural testing. A finite element method was investigated for inclusion in the code to generate the nonlinear stiffness matrix for the beam elements in KRASH. Recommendations are presented for the modification of the computer code to accommodate the nonlinear analysis of the vehicle. A preliminary assessment of the effect of composite materials on the crashworthiness of aircraft structures was conducted using the KRASH code. The influence of composite material mechanical properties such as anisotropy, ultimate strength, torsional stiffness and nonlinearity on the dynamic response was investigated. Very minor influence on the vehicle responses were observed for the range of parameters investigated. Author

N90-25957*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN OVERVIEW OF THE JOINT FAA/NASA AIRCRAFT/GROUND RUNWAY FRICTION PROGRAM
THOMAS J. YAGER Feb. 1989 16 p Submitted for publication
(NASA-TM-103486; NAS 1.15:103486) Avail: NTIS HC A01/MF A01 CSCL 01/3

There is a need for information on runways which may become slippery due to various forms and types of contaminants. Experience has shown that since the beginning of all weather aircraft operations, there have been landing and aborted takeoff incidents and/or accidents each year where aircraft have either run off the end or veered off the shoulder of low friction runways. NASA Langley's Landing and Impact Dynamics Branch is involved in several research programs directed towards obtaining a better understanding of how different tire properties interact with varying pavement surface characteristics to produce acceptable performance for aircraft ground handling requirements. One such effort, which was jointly supported by not only NASA and the FAA but by several aviation industry groups including the Flight Safety Foundation, is described. Author

N90-25958# General Accounting Office, Washington, DC. Resources, Community, and Economic Development Div.
AVIATION SAFETY: CONDITIONS WITHIN THE AIR TRAFFIC CONTROL WORK FORCE. FACT SHEET FOR CONGRESSIONAL REQUESTERS
Apr. 1989 131 p
(GAO/RCED-89-113FS; B-222217) Avail: NTIS HC A07/MF A01; also available from GAO, Gaithersburg, MD HC first five copies are free, additional copies $2.00

The complete 1988 questionnaire responses of air traffic controllers, supervisors, and facility managers (the air traffic work force) are compared with those of the air traffic control work force survey done in 1985. The 1985 questions were replicated, and new ones were added. The survey and scope of and methodology are described and the responses to each question are summarized for the air route traffic control centers, which control flights between airports and over oceanic routes; the largest terminals; and the overall combined responses of centers and terminals. The questions and responses address a variety of air traffic issues facing the Federal Aviation Administration (FAA), including, among others, work load, staffing, overtime, training, morale, and system safety. The perceptions of the air traffic work force on these subjects have changed little since the 1985 survey. J.P.S.

N90-25959# General Accounting Office, Washington, DC. Resources, Community, and Economic Development Div.
AVIATION SAFETY: SERIOUS PROBLEMS CONTINUE TO TROUBLE THE AIR TRAFFIC CONTROL WORK FORCE. REPORT TO CONGRESSIONAL REQUESTERS
Apr. 1989 59 p
(GAO/RCED-89-112; B-222217) Avail: NTIS HC A04/MF A01; also available from GAO, Gaithersburg, MD HC first five copies free, additional copies $2.00

Federal Aviation Administration (FAA) air traffic controllers, supervisors, and managers were surveyed to determine how they feel about their working conditions. This updates a similar study done in 1985. Eighty-four facilities were surveyed on various issues including staffing adequacy, training of new controllers, morale, and safety of the air traffic control system. Five thousand ninty-eight out of six thousand four hundred sixty-nine questionnaires were returned. The Flight Safety Foundation, an independent international membership organization dedicated solely to the improvement of flight saftey, evaluated the questionnaire results and provided its views on safety. The Foundation concluded that the air traffic control system is not unsafe, remains essentially unchanged from 1985, and is less than desirable. FAA has planned or undertaken several nationwide initiatives to address work force concerns. These include plans for improving its recruitment and hiring techniques, revolutionizing the way it trains air traffic controllers, and using a pay demonstration project to attract personnel to hard-to-staff facilities. J.P.S.

N90-25961# Flight Safety Foundation, Inc., Arlington, VA.
SECOND ANNUAL INTERNATIONAL CONFERENCE ON AGING AIRCRAFT
1989 262 p Conference held in Baltimore, MD, 3-5 Oct. 1989 Sponsored by FAA, Atlantic City, NJ
(AD-A222715; DOT/FAA/CT-89/35) Avail: NTIS HC A12/MF A02 CSCL 05/1

This document contains the formal presentations made at the

2nd Annual International Conference on Aging Aircraft. It includes status reports in the areas of transport and commuter aircraft certification, maintenance, research and development, the ATA/AIA airworthiness assurance task force and efforts by NASA. Also included are detailed presentations on the research and development efforts underway and planned in the areas of structural fatigue, loads, corrosion, nondestructive testing/inspection and human factors. GRA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A90-42655#
THE CANADIAN AIRSPACE SYSTEMS PLAN - MAINTAINING THE SAFETY AND EFFICIENCY OF THE AIR NAVIGATION SYSTEM
G. S. AITKEN (Transport Canada, Ottawa) IN: Annual General Meeting of the Canadian Aeronautics and Space Institute, 36th, Ottawa, Canada, May 15, 16, 1989, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1989, p. 6-1 to 6-13.

The Canadian Airspace System Plan (CASP) entails an evolutionary development of the technical infrastructure of the Canadian Air Navigation System, encompassing facility and equipment modernization in ATC, flight services, aviation weather forecasting, communications/navigation/surveillance ground-to-air systems, intra- and interfacility communication networks, and maintenance and operations support equipment. Greater safety, capacity, productivity, and economy will be achieved through the more extensive use of automation, and the consolidation of certain facilities and services. Major expenditures will be a Radar Modernization Project, an MLS project, and the Canadian Automated Air Traffic System Project. O.C.

A90-42924
ESTIMATION OF THE EFFICIENCY OF VARIOUS OPERATIONAL MODES OF A NAVIGATION COMPLEX [K OTSENKE EFFEKTIVNOSTI RAZLICHNYKH REZHIMOV FUNKTSIONIROVANIIA NAVIGATSIONNOGO KOMPLEKSA]
A. A. RESSIN, A. D. TROIANOVSKII, and B. IA. TSIL'KER (Rizhskii Institut Inzhenerov Grazhdanskoi Aviatsii, Riga, Latvian SSR) Priborostroenie (ISSN 0021-3454), vol. 33, March 1990, p. 49-53. In Russian. refs

Simple expressions are obtained for the probability that the lateral errors of a navigation complex exceed the set limits. Results are presented for three operational modes: with averaging of signals from three systems, majority processing of signals, and correction of the growing errors of a single system. A numerical example involving lateral deviations from a flight path over the North Atlantic is presented. B.J.

A90-42990
STABILITY AND CONTROLLABILITY IN PROPORTIONAL NAVIGATION [USTOICHIVOST' I UPRAVLIAEMOST' PRI PROPORTSIONAL'NOI NAVIGATSII]
V. L. KAN and A. S. KEL'ZON Prikladnaia Matematika i Mekhanika (ISSN 0032-8235), vol. 54, May-June 1990, p. 373-383. In Russian. refs

The proportional navigation methods developed in earlier studies (Kan and Kelzon, 1965, 1968) are extended to the case of arbitrary values of the navigation constant, including the case where this constant is less than 1 or ranges from 1 to 2. It is shown that the introduction of motion on the Riemann surface makes it possible to avoid ambiguities associated with the right-hand terms of the differential equations used. By extending the parameter plane partitioning method to the general case, it is possible to evaluate the motion in qualitative terms (including stability and controllability) without solving the equations. The discussion is illustrated by an example. V.L.

A90-43230
EXTENDED COMMUNICATION PATH LENGTH SCINTILLATION MEASUREMENTS AND MODEL - A DISCUSSION OF RESULTS
ROBERT J. FELDMANN (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: Propagation engineering; Proceedings of the Meeting, Orlando, FL, Mar. 28-30, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 28-37. refs

An element of USAF's Laser Airborne Communications Experiment (LACE) program involved the collection and analysis of amplitude scintillation in order to ascertain extended propagation path lengths. Since LACE terminals used direct detection of pulsed laser energy, the random variations in received signal strength were used to evaluate atmospheric turbulence-induced amplitude scintillations. The data were then reduced and compared with an extended path length channel model in order to verify model performance against the collected data. A reasonable degree of correlation is found between model and data, consistent with current understanding of the effect of the communications channel on system performance. O.C.

A90-43681#
UK REFERENCE STATION FOR NAVSTAR GPS
J. I. R. OWEN (Royal Aerospace Establishment Farnborough, Air Navigation Systems Div., England) IN: Institute of Navigation Satellite Division, International Technical Meeting, 2nd, Colorado Springs, CO, Sept. 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 61-65.

The requirements for establishing a reference station for Navstar GPS are discussed. The need for signal-in-space data for GPS and the data base for predicting GPS performance are briefly addressed. GPS flight testing and integrity and reliability studies are examined. The structure of the reference station is described. C.D.

A90-43686#
RANGE APPLICATIONS JOINT PROGRAM OFFICE GPS RANGE SYSTEM DATA LINK
MELVIN BIRNBAUM, JOSEPH J. BLANDA (Interstate Electronics Corp., Anaheim, CA), R. FRANK QUICK, JR., and KLEIN S. GILHOUSEN (Qualcomm, Inc., San Diego, CA) IN: Institute of Navigation Satellite Division, International Technical Meeting, 2nd, Colorado Springs, CO, Sept. 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 103-108.

The Range Application Joint Program Office (RAJPO) Range System is intended as a time, space, position information (TSPI) measurement facility for U.S. military test and training ranges using GPS range equipment. The RAJPO data link is being developed to support GPS positioning data collection and processing. This paper discusses the data link message capacity required to support the generation and downlinking of GPS navigation solutions. Data link networking is also addressed, with emphasis on the features required to provide high-reliability message transmission while downlinking data from highly dynamic aircraft. Integration of the data link into range data processing and control facilities is discussed, along with data link features allowing cooperative interoperation among adjacent ranges. C.D.

A90-43700#
EMBEDDED GPS - THE CANADIAN MARCONI APPROACH
JAMES M. BROWN and PATRICK J. HUI (Canadian Marconi Co., Kanata, Canada) IN: Institute of Navigation Satellite Division, International Technical Meeting, 2nd, Colorado Springs, CO, Sept. 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 199-205. refs

This paper presents a new embeddable GPS card set. This

GPS sensor is designated the CMA-2122. It uses the same software algorithms and very similar hardware architecture as the earlier CMA-786 GPS Navigation Receiver. Three circuit cards totalling 50 squre inches and consuming only 7.5 W implement a complete 2-channel GPS sensor suitable for embedding in other avionics navigation equipment, land vehicle navigation equipment, or time-transfer devices. A high-speed 8-bit parallel interface and an RS-232 interface are provided to facilitate this integration. A separate power supply, mechanical housing, and antenna/pre-amp are required. The satellite acquisition and tracking algorithms, the Kalman filter, the navigaton software, and the hardware implementation are described. Author

A90-43701#
ROCKWELL INTERNATIONAL'S MINIATURE HIGH PERFORMANCE GPS RECEIVER
DAVID E. GRAY and DANIEL C. FORSETH (Rockwell International Corp., Collins Government Avionics Div., Cedar Rapids, IA) IN: Institute of Navigation Satellite Division, International Technical Meeting, 2nd, Colorado Springs, CO, Sept. 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 207-215.

The architecture of the miniature GPS receiver, is presented along with the existing features of the receiver, its expansion capabilities, and future possibilities. The size, weight and power of the GPS receiver have been reduced by incorporating advanced large-scale integration technologies. Hardware functional partitioning has been aligned with the four major GPS operational areas to allow maximum adaptability of the receiver design to new technologies and applications. Necessary software changes were restricted to functional repartitioning to take advantage of the improved hardware partitioning and scale factors, and to make any required changes. Reduction of size, weight, and power requirements has been achieved without sacrificing functional compatability with current DOD standard GPS user equipment. R.E.P.

A90-43705#
USCG HH-65A/SRR GPS INTEGRATION AND TEST RESULTS
LAMAR T. SEIFUDDIN (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: Institute of Navigation Satellite Division, International Technical Meeting, 2nd, Colorado Springs, CO, Sept. 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 245-251.

The integration of GPS into the HH-65 A avionics system is examined. The capabilities of the GPS integrated avionics system are discussed. The integrated avionics system is evaluated using laboratory, ramp, and flight tests. It is observed that the GPS is successfully integrated into the HH-65A avionics systems and that the integrated system enhances navigation accuracy for offshore operations and has a highly accurate back-up navigation capability. I.F.

A90-43707#
REDUCED ORDER INS/GPS GUIDED UNMANNED AIR VEHICLE STUDY
TYSEN MUELLER and ALGYTE CABAK (Trimble Navigation, Ltd., Sunnyvale, CA) IN: Institute of Navigation Satellite Division, International Technical Meeting, 2nd, Colorado Springs, CO, Sept. 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 263-268. refs

The accuracy of several reduced order INS/GPS navigators for guiding a midrange UAV was evaluated. No more than three axes of inertial guidance were used by these navigators in order to reduce the cost of the navigation system. UAV performance was evaluated for a reconnaissance operation of two target areas. Dead reckoning models were derived utilizing the linear control error dynamics of the UAV, based on the nominal aerodynamic force and moment partial derivatives, with control error coefficients included in the onboard Kalman filter. In substituting these dead reckoning models for the corresponding inertial sensors in a GPS/INS navigator, less expensive reduced order INS/GPS navigators were formulated and evaluated. For the five navigators considered, a GPS/AHRS (attitude heading reference system) navigator, using an axial accelerometer and three gyros, provided a cost effective alternative to a full GPS/INS navigator. R.E.P.

A90-43708#
A FLIGHT TEST COMPARISON OF TWO GPS/INS INTEGRATION APPROACHES
RONALD B. DAYTON (Boeing Aerospace and Electronics, Seattle, WA) and JOHN T. NIELSON (NAVSYS Corp., Monument, CO) IN: Institute of Navigation Satellite Division, International Technical Meeting, 2nd, Colorado Springs, CO, Sept. 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 269-273.

A test flight was conducted to demonstrate the practicality of two different real-time GPS/INS integrations using the same hardware. Performance advantage is indicated by using an integrated filter approach that uses the unfiltered GPS pseudo-range and delta-range measurements as inputs to the system filter. The flight test demonstrated the workability of two different real-time GPS/INS integrations employing the same hardware. It is concluded that this integrated approach can lead to superior navigation performance, probably due to the tighter integration that allows the system to take full advantage of all available measurements. R.E.P.

A90-43710#
F-16/GPS INTEGRATION TEST RESULTS
SCOTT H. DELLICKER (U.S. Army, Yuma Proving Ground, AZ) and DAVID HENKEL (Computer Sciences Corp., Edwards AFB, CA) IN: Institute of Navigation Satellite Division, International Technical Meeting, 2nd, Colorado Springs, CO, Sept. 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 295-303. refs

An avionics system, the F-16 Block 40, incorporating a Kalman filter into the fire control computer to achieve highly accurate horizontal navigation data using GPS as a navigation sensor is presented. This integrated system supplies automatic system altitude calibration and an in-flight alignment capability of the INS. It is indicated that GPS user equipment integrated into the host vehicle navigation or weapons computer provides a space positioning reference with superior accuracies. As a result, the operational potential of this system integration is greatly improved. R.E.P.

A90-43713#
A ROBUST RAIM SCHEME USING GPS/GLONASS SYSTEMS
WAI L. TSANG and BARRY A. STEIN (Science Applications International Corp., McLean, VA) IN: Institute of Navigation Satellite Division, International Technical Meeting, 2nd, Colorado Springs, CO, Sept. 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 373-378. refs

The FAA has questioned the integrity of GPS with its selective availability (SA) turned on. Now investigators and researchers are studying self-contained receiver autonomous integrity monitoring (RAIM) methodologies. These procedures can range from the intuitively simple least squares method, which can be mechanized in a single microprocessor, to a complex bank of Kalman filters, which could only be mechanized with super/parallel signal processors. A scenario where the U.S. GPS and the Soviet GLONASS are providing NAVAID for civil aviation use is studied and the issues pertaining to a joint operation are discussed. Combined methodology which draws on the desirable features associated with these RAIM methods is then proposed. The possibilities of a hybrid GPS/GLONASS receiver are also discussed. R.E.P.

A90-43714#
RAIM - AN IMPLEMENTATION STUDY
J. M. BROWN (Canadian Marcon Co., Kanata, Canada), H. SCHWARTZ, and D. KOLODY (Carleton University, Ottawa, Canada) IN: Institute of Navigation Satellite Division, International Technical Meeting, 2nd, Colorado Springs, CO, Sept. 27-29, 1989,

Proceedings. Washington, DC, Institute of Navigation, 1989, p. 379-388. refs

The commercial airline community has been searching for a method of assuring the integrity of the GPS position fix. To date, two broad techniques have been identified, the GPS integrity channel (GIC) and receiver autonomous integrity monitoring (RAIM). As RAIM appears to be the more immediate of the two techniques to be available, various algorithms for this method are discussed. It is noted that software complexity, CPU processing load, and the effects of aircraft dynamics and selective availability on the probability of false alarm, probability of false dismissal, and time-to-alarm of the selected algorithms are of special concern. It is recommended that a mixture of the two algorithms be employed. R.E.P.

A90-43724#
AIRCRAFT SEPARATION BY SYNCHRONIZED TRANSPONDER INTERROGATION (ASSTI)
SHERMAN G. FRANCISCO (IBM Corp., Rockville, MD) IN: Institute of Navigation Satellite Division, International Technical Meeting, 2nd, Colorado Springs, CO, Sept. 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 475-481. Research sponsored by IBM Corp.

The ASSTI concept is presented and an analysis of major system error sources which establishes the practicality of this noninterfering aircraft separation aid, which can improve safety in the national airspace, is studied. The customary FAA traffic monitoring system is not compromised as no additional transmissions are introduced with this concept. A minimum ATC-transponder is all that is required of the traffic aircraft. Thus, only modest navigation capabilities are necessary of the ASSTI equipped aircraft to precisely monitor its local traffic for separation. A precision interrogator time scale and a published site survey are required of the ATC radar beacon system facilities. Multiple-beacon interrogation that is factored into the FAA NAS strategy, will provide nearly complete coverage in most nonmountainous regions. R.E.P.

A90-45200
AIRBORNE EARLY WARNING RADAR
WILLIAM C. MORCHIN, ED. Norwood, MA, Artech House, 1990, 474 p. No individual items are abstracted in this volume.
Copyright

Aspects of airborne early warning radar are discussed. The environment that affects radar performance in target scattering fundamentals, atmospheric effects, and clutter is described. An original and thorough approach to the formulation of an airborne early warning radar design is presented which ranges from assessing mission requirements to specifying waveform, antenna sidelobe requirements, antenna size, and transmitter power for minimum weight. The possible radar architecture approaches are presented, indicating the tradeoffs and available options. RF receivers and signal processing are covered, including the ambiguity function analysis of airborne radars with MTI capability. A technique for optimum apportionment of power and time between radar functions for a phased array radar system is presented. ECCM is considered, including an assessment of ECM counter-ESM techniques and the numerical assessment of ECCM techniques. Aircraft effects and limitations in AEW radar are addressed. C.D.

A90-45226
INSTITUTE OF NAVIGATION, ANNUAL MEETING, 45TH, ALEXANDRIA, VA, JUNE 27-29, 1989, PROCEEDINGS
Meeting supported by Adroit Systems, Inc., Honeywell, Inc., Rockwell International Corp., et al. Washington, DC, Institute of Navigation, 1989, 189 p. For individual items see A90-45227 to A90-45238.

Topics presented include terrestrial applications of loran, preliminary orbit determination, a midcourse correlator/tracker for SDI, the design of a miniature high-precision ovenized oscillator for GPS receivers, and Omega compass applications. Also presented are the application of digital technology to Omega simulation and monitoring; biased and unbiased estimates in GPS processing, GPSNOTAM, a demonstration system for GPS status notification; and potential interference sources to GPS and solutions appropriate for applications to civil aviation. R.E.P.

A90-45227#
FLIGHT SAFETY PERFORMANCE OF THE MICROWAVE LANDING SYSTEM
DANIEL J. BERNINGER (Galaxy Scientific Corp., Warminster, PA) IN: Institute of Navigation, Annual Meeting, 45th, Alexandria, VA, June 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 9-13. Research supported by the Galaxy Scientific Corp. refs

A historical background and an overview of the Instrument Landing System (ILS) and the Microwave Landing System (MLS) are presented with a discussion of the major issues that include flight safety, capacity, MLS debate, weather, and implementation considerations. MLS is scheduled to become operational progressively during the next 10 years, supplanting the ILS as the international standard landing aid. Though MLS has been demonstrated to be superior to ILS in both performance and reliability, debate still continues on its relative merits. Why flight safety has not been an issue is discussed, and observations on the flight safety of MLS from a systems point of view are presented. Collocation of ILS and MLS poses additional complications for aircraft using ILS in the same airspace as aircraft under MLS guidance. Thus, to increase flight safety, efforts must be directed at reducing these possible hazardous situations, which demonstrates the need for the Microwave Landing System. R.E.P.

A90-45232#
DIFFERENTIAL OMEGA/VLF AS A WORLD-WIDE NAVIGATION AID IN THE 21ST CENTURY
A. STRATTON (Terrafix, Ltd., Welham Green, England) IN: Institute of Navigation, Annual Meeting, 45th, Alexandria, VA, June 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 87-95. refs

An evaluation is made of the factors determining the accuracy with which the phase of a VLF transmission can be predicted at a given location and, as a consequence, its inherent accuracy as a radio navigation aid. Specific attention is given to differential operation. If GPS were the only global aid, it might be necessary to increase the GPS constellation by three, to meet the stringent safety requirements of civil aviation. Application of Omega on both local and global scales is discussed. The need for an alternative to GPS, economics, and the relationship of Omega to other alternatives, are the major areas addressed. It is estimated that maintaining the current eight Omega stations and adding two additional stations while introducing a worldwide differential monitoring service would cost a fraction of the total costs of augmenting GPS. It is shown that, by applying recent research into VLF propagation and modern communication and data processing techniques, the full potential of Omega/VLF can be achieved. R.E.P.

A90-45233#
OMEGA - A LOW-COST PRECISION SYNCHRONIZER
EDWARD SAVAGE (Telephonics Corp., Huntington, NY) and GEORGE B. LITCHFORD (Litchford Electronics, Inc., Northport, NY) IN: Institute of Navigation, Annual Meeting, 45th, Alexandria, VA, June 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 97-100.

The Omega Navigation System employs eight globally-distributed ground stations to transmit a pattern of super stable 10 to 14 kHz frequencies in the VLF band. Because of the propagation characteristics of signals transmitted at these frequencies, a reciever can receive three or more stations anywhere on the earth's surface at any time, day or night. Omega has provided land, air, and marine users reliable worldwide navigation for over two decades. A recent development is the use of Omega signals for a tracking and positioning system. This paper describes a concept for exploiting this global resource to generate precision timing triggers to obtain highly precise, localized positioning data

for display of land/air/marine traffic. It then postulates the use of the same concepts to synchronize data distribution networks to provide this data to the various Command and Control (C2) hierarchies. Author

A90-45234#
OMEGA COVERAGE - ANALYTICAL AND EMPIRICAL METHODS AND SOLUTIONS
E. R. SWANSON (U.S. Navy, Naval Ocean Systems Center, San Diego, CA) IN: Institute of Navigation, Annual Meeting, 45th, Alexandria, VA, June 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 111-117. refs

The most important statement about Omega coverage is that the system is in continuous use by many of the world's airlines to provide a trillion passenger miles of safe and efficient navigation annually on global routes. As the first electronic navigation system deliberately designed with redundancy, Omega is extraordinarily robust. The problem is selecting which signals to use in given circumstances. Omega signals may interfere with themselves through two methods. A conventional 'short path' signal may be contaminated by a counterpart propagating on a 'long path' more than half way around the world. Alternatively, several propagation modes may be supported rather than the one required for navigation. Practical guidance on signal usage has been developed using overlays, a parametric formulation, local assessments and a computer program called ACCESS. These analyses have been largely confirmed through regional validations. Author

A90-45236#
INTEGRATION OF THE LTN-72 INS WITH THE DOD GPS 3A SET
J. BASS (U.S. Navy, Naval Air Development Center, Warminster, PA), H. S. YANG, R. BOEBEL, and C. PIERCE (Litton Aero Products, Moorpark, CA) IN: Institute of Navigation, Annual Meeting, 45th, Alexandria, VA, June 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 139-149.

System design studies of INS-GPS integration are presented with the digital interface between the GPS and INS consisting of four 2-wire digital buses. The present specification covers connections between a single GPS, dual INS systems, and various aircraft systems. Aircraft interface is multiuser and handles five different aircraft configurations. The study phase objective was to develop integration techniques that would optimize performance while still meeting the range of operator requirements. The eventual design and development procedures following the initial study phase are described. Development of the program is discussed in five major areas: covariance analysis and simulations, using a real time simulator for software development, static testing, van testing, and flight testing. A number of flights were made to test the basic performance of the system in its different operating modes, testing both single and dual operation modes. Results of these flight tests indicate that all accuracy requirements were met. R.E.P.

A90-45238#
GPSNOTAM - A DEMONSTRATION SYSTEM FOR GPS STATUS NOTIFICATION
PAUL M. CREAMER, KENNETH A. TENCH (Analytic Sciences Corp., Reading, MA), and KAREN L. VAN DYKE (DOT, Transportation Systems Center, Cambridge, MA) IN: Institute of Navigation, Annual Meeting, 45th, Alexandria, VA, June 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 189-194.

The FAA is formulating means for the dissemination of NAVSTAR/GPS-related navigation information to flight crews. New approaches for dissemination times and locations where GPS does not meet minimum accuracy requirements for the enroute and nonprecision approach phases of flight are of particular interest. Requirements for a workstation which will show GPS navigation status information in a format that is useful to flight service station briefers are being established. A set of strawman requirements developed for the workstation, the GPSNOTAM design developed to meet the strawman requirements, and a set of proposed future requirements for the workstation based in part on preliminary reaction to GPSNOTAM are described. A number of specialized procedures were introduced in GPSNOTAM to increase processing speed. As an example, a 'hardwired' matrix inversion is implemented in GPSNOTAM's horizontal dilution of precision algorithm which avoids calculation of the unnecessary off-diagonal terms. Finally, the future extension of GPSNOTAM would be to quickly provide the briefer with all the data relevant to a given flight in a single integrated display. R.E.P.

A90-45432
DEVELOPMENT OF OBSTACLE CLEARANCE CRITERIA AND STANDARDS FOR MLS AND MLS/RNAV PRECISION APPROACHES AND DEVELOPMENT OF AN MLS COLLISION RISK MODEL
RALPH D. SEXTON, ALAN B. JONES (FAA, Oklahoma City, OK), and JAMES H. YATES (Central State University, Edmond, OK) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 11 p.
(SAE PAPER 892215) Copyright

To develop obstacle clearance criteria and standards for MLS procedures development, the accuracy with which an aircraft can be flown along a defined approach path must be determined. Error modeling, simulator tests, and flight tests are used to determine the distributions of the flight paths about the specified approach paths. Isoprobability contours are derived from which obstacle clearance criteria are developed. The error models are also used in developing a collision risk model for use in evaluating the cumulative risk of an aircraft collision with an obstacle for specified aircraft performance and obstacle environment. Author

A90-45433
SIMULATOR EVALUATION OF 'BASIC' MODE BACK AZIMUTH ISSUES IN DEPARTURE AND MISSED APPROACH USAGE
BARRY C. SCOTT (FAA, Moffett Field, CA) and TSUYOSHI GOKA (T. Goka Avionics, Sunnyvale, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 33 p.
(SAE PAPER 892216) Copyright

Two piloted simulation studies were conducted to examine the operation issues involved in using front and back azimuth functions of the Microwave Landing System (MLS) in precision departure and missed approach procedures. These studies provided data to determine the optimum back azimuth signal sensitivity, to establish operationally acceptable limits and procedures for the use of back azimuth guidance, and to determine the optimum technique for switching from front to back azimuth guidance. Author

A90-45434
SIMULATION OF MLS-ATC PROCEDURES IN THE NEW YORK AND SAN FRANCISCO TERMINAL CONTROL AREAS
BARRY C. SCOTT (FAA, Moffett Field, CA), TSUYOSHI GOKA (T. Goka Avionics, Sunnyvale, CA), and JIM DARGUE SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 32 p.
(SAE PAPER 892217) Copyright

Two recent simulation studies examined the use of the Microwave Landing System (MLS) in the terminal area environment. In the first study, using models of the New York Terminal Areas, multiple scenarios involving instrument Landing System (ILS) and MLS capabilities were simulated to evaluate air-traffic-control (ATC) procedures and to identify future efforts needed to ensure that ATC personnel will be able to facilitate the use of the MLS. The test disclosed several procedural issues that require further study and showed that an all-MLS environment significantly reduced controller workload. The second study examined MLS procedures for the San Francisco (SFO) Terminal Area and explored the operational feasibility of an offset azimuth radial approach to SFO runway 28R using basic mode MLS avionics. Author

A90-45435
MLS RNAV ACCURACY FLIGHT TESTS
CLIFF MACKIN and MICHAEL MAGROGAN (FAA, Washington,

DC) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 23 p. refs
(SAE PAPER 892218) Copyright

This paper discusses the results of a series of flight tests conducted at various locations. The purpose of the flights were to obtain accuracy performance measures. Flights were conducted at the FAA Technical Center, Atlantic City, NJ, Tamiami Airport in Miami, FL, and Lebanon, NH. The flight tests conducted at Atlantic City included computed centerline approaches in which the azimuth transmitter was offset 500 feet and 1000 feet from the runway centerline. The Lebanon flight test consisted of a computed centerline approach where the azimuth is more than 400 feet off the runway centerline. A series of precision approaches were conducted during the flight tests at Tamiami Airport. These included a multisegment glide path on the runway where the equipment was sited, an approach to a parallel runway (3500 feet offset) and an approach to an intersecting runway. Results of these flight tests indicate that category I computed centerline operations could be conducted across a wide range of MLS siting conditions.
Author

A90-45436
ANALYTICAL STUDIES FOR COMPUTED CENTER LINE OPERATIONS
CHRIS WOLF and BARRY BILLMAN (FAA, Washington, DC) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 14 p.
(SAE PAPER 892219) Copyright

This paper presents the results of several analytical studies performed to provide information on computed centerline operations using Microwave Landing System (MLS) Area Navigation equipment. These studies addressed several issues. These issues included factors effecting positional accuracy, use of elevation information, and computed signal quality. Data collection flights were performed to validate the analytical results. During these tests the azimuth station was offset 500 and 1000 feet from the runway centerline. Results of these studies indicate that category I computed certerline operations could be conducted across a wide range of MLS siting conditions.
Author

N90-25122# Technology Planning, Inc., Rockville, MD.
NATIONAL AIRSPACE SYSTEM (NAS) SOFTWARE LIFE CYCLE MANAGEMENT STUDY Final Report
Mar. 1990 109 p
(Contract DTOS59-88-C-00064)
(AD-A221180; DOT/FAA/SE-90/1; DOT/FAA/CT-TN90/01)
Avail: NTIS HC A06/MF A01 CSCL 12/5

In implementing FAA-STD-026 (based on DOD-STD-216 7A) for acquiring NAS software and adopting the Ada Programming Language as the single high order language for NAS, several issues were raised pertaining to the differences in software development, testing, and maintenance practices between the NAS acquisition and operations support organizations. Some of the dificiences are identified and documented with respect to the existing process and guidelines used to acquire and maintain NAS software and recommends an action plan to address the identified deficiencies. In addition, it presents an overview (list of products and activities) of the NAS System Life Cycle management process within the context of a major systems acquisition, as described by FAA Orders 18100.8. The process is applicable to non-major systems as well.
GRA

N90-25123# Federal Aviation Administration, Atlantic City, NJ.
REPLICATION OF NASPAC DALLAS/FORT WORTH STUDY
DOUGLAS BAART, ANNY CHEUNG, JOSEPH RICHIE, and ARTHUR POMERANTZ (Computer Technology Associates, Inc., Lanham, MD.) Jul. 1990 27 p
(Contract F2006E)
(DOT/FAA/CT-TN90/26) Avail: NTIS HC A03/MF A01

A simulation study conducted at the Technical Center using the National Airspace System Performance Analysis Capability (NASPAC) is described. The simulation was an attempt to reproduce a study by the MITRE Corporation which examined the effects of the Dallas/Fort Worth (D/FW) Metroplex Plan on NAS delays and throughput. The results closely approximated the results found in the earlier simulation.
Author

N90-25965# Technische Univ., Brunswick (Germany, F.R.). Fakultaet fuer Maschinenbau und Elektrotechnik.
THE DISTURBANCE PROCESSES ON THE DATA LINKS OF THE MODE-S AIR TRAFFIC CONTROL SYSTEM Ph.D. Thesis [DIE STORPROZESSE AUF DEN DATENSTRECKEN DES MODE-S-SYSTEMS DER FLUGSICHERUNG]
FRANK ZIEGLER 1989 141 p In GERMAN
(ETN-90-96960) Avail: NTIS HC A07/MF A01

The influence of system-inherent disturbances on the behavior of both data links used in the mode-S air traffic control system was investigated. The characteristics of the uplink and downlink signals and the cyclic error correction code are outlined. A hardware model was developed because the present system exists only in a few test stations. The different disturbances were analyzed for the downlink as well as for the uplink signals. The probabilities for the occurrence of the important phenomena test error and signal breakdown were determined in the case of signal overlapping.
ESA

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A90-42520
PRINCIPLES UNDERLYING THE INTEGRATION OF AN AIRCRAFT AND ITS ENGINE [OSNOVY INTEGRATSII SAMOLETA I DVIGATELIA]
OLEG K. IUGOV and OLEG D. SELIVANOV Moscow, Izdatel'stvo Mashinostroenie, 1989, 304 p. In Russian. refs
Copyright

This work examines methods for choosing the parameters, operating modes, and control laws of an aircraft and its powerplant that assure efficient integrated operation. Attention is given to methods for calculating the aerodynamic and weight characteristics of the airframe and the powerplant and for determining the main aircraft flight requirements with allowance for possible constraints. Examples of optimization using CAD techniques are presented.
B.J.

A90-42656#
DEVELOPING THE CANADAIR REGIONAL JET AIRLINER
ROBERT A. WOHL (Canadair, Regional Jet Div., Montreal, Canada) IN: Annual General Meeting of the Canadian Aeronautics and Space Institute, 36th, Ottawa, Canada, May 15, 16, 1989, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1989, p. 8-1 to 8-9.

An account is given of the benefits accruing to Canadair's Regional Jet (RJ) predevelopment activities from a formally defined design/marketing-phase approach. The RJ is a 50-passenger derivative of the current Challenger 601-series business jet. Preliminary design changes encompass a total of 240 inches in fuselage extensions, increased wing area, strengthened landing gear and brakes, and modification of the flight control system. The design/marketing phase resulted in signed customer commitments for 62 aircraft, leading to approval of the RJ program.
O.C.

A90-42664#
THE DASH 8 SERIES 400 REGIONAL AIRLINER
DAVID M. SCHENCK (Boeing Canada, de Havilland Div., Downsview) IN: Annual General Meeting of the Canadian Aeronautics and Space Institute, 36th, Ottawa, Canada, May 15,

16, 1989, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1989, p. 26-1 to 26-16.

The Dash 8 regional airliner's Series 400 design and performance specifications were formulated on the basis of intensive market research, which encompassed numerous interviews with more than sixty airlines operating throughout the world. Strong market demand was ascertained for a 66-70 passenger aircraft that combined excellent large-turboprop economics with the 350-kt cruise speed required for longer regional airline routes emerging in the 1990s. The next-generation turboprop engines under consideration for the Series 400 will turn novel six-bladed propellers designed for high efficiency and low noise. O.C.

A90-42672#
BD-10J SUPERSONIC HOMEBUILT AIRCRAFT
JAMES R. BEDE (Advanced Aircraft, Inc., Cleveland, OH) IN: Annual General Meeting of the Canadian Aeronautics and Space Institute, 36th, Ottawa, Canada, May 15, 16, 1989, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1989, p. 38-1 to 38-12.

The BD-10J is a home-built two-seat, single-engine aircraft has a gross weight of under 3000 lbs and employs a 3000-lb thrust class engine such as the GE CJ-610 to reach Mach 1.4. Both conventional materials and such advanced materials as Kevlar-reinforced Nomex-honeycomb sandwich are used in the structure. Pilot training requirements for this aircraft will be substantially reduced by the simplicity of the all-mechanical control system employed. Wing loading will be sufficiently low for landing and takeoff speeds below 100 kts, obviating high-pressure tires and antiskid brakes. O.C.

A90-42673#
SOME CONSIDERATIONS IN ULTRA LIGHT AIRCRAFT DESIGN
J. F. MARTIN IN: Annual General Meeting of the Canadian Aeronautics and Space Institute, 36th, Ottawa, Canada, May 15, 16, 1989, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1989, p. 41-1 to 41-11. refs

An analysis of practice in the field of ultralight aircraft design discloses a number of generalizations of use in the design of new aircraft of this type. Investigation into the flying qualities of such aircraft leads to recommendations concerning the horizontal and vertical tail volume ratios necessary to assure satisfactory flying characteristics. The results of full-scale wind-tunnel tests on an ultralight aircraft suggest measures which should be adopted in any new design in order to satisfy the stalling speed requirements as specified in Part 103 of the United States air regulations. Author

A90-42768#
FOCUSING PROPULSION AND LIFT SYSTEM DEVELOPMENT FOR AN EVOLVING SPECIAL OPERATIONS AIRCRAFT
E. A. LAKE (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 9 p. (AIAA PAPER 90-2277)

Initial efforts involved in structuring an advanced propulsion and lift system technology demonstration program are discussed. Key performance parameters and operating conditions are reviewed and airframe configuration options are examined. The identification of technology needs common to concepts meeting postulated mission requirements is addressed, and the designation of initial propulsion and lift system characteristics is considered. The development of subsystems and subsystem components is discussed. C.D.

A90-43152
HIGH-PERFORMANCE EHA CONTROLS USING AN INTERIOR PERMANENT MAGNET MOTOR
THOMAS M. JAHNS (General Electric Co., Schenectady, NY) and RICHARD C. VAN NOCKER (General Electric Co., Aircraft Control Systems Dept., Binghampton, NY) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. 26, May 1990, p. 534-542. refs
Copyright

A controller for a high-performance electrohydrostatic actuator (EHA) using an interior permanent magnet (IPM) synchronous motor to produce servo motion is described. The buried-magnet design of the IPM motor yields desired characteristics such as high efficiency, robust rotor construction, and wide operating speed range. Power converter size is minimized by using insulated-gate bipolar transistor power switches combined with high-voltage integrated-circuit gate drivers in phase-leg power modules. Experimental results for the demonstrator motor-controller hardware rated at 12 HP (continuous) are presented, confirming the IPM motor drive's performance. I.E.

A90-43764
THE STANDARD-SETTING HORNET
ROY BRAYBROOK Air International (ISSN 0306-5634), vol. 38, May 1990, p. 221-229, 264.
Copyright

The evolutionary history of the F/A-18 family is traced from the project studies beginning in 1966 to the current variations in operation today with U.S., Canadian and Spanish armed forces. During early development of this aircraft numerous operational and installation problems involving airframe, powerplant and system avionics were encountered. These difficulties and how they were resolved are presented in considerable detail. Some of the major problems described include aircraft weight and balance, roll rate deficiency and engine compressor blade fatigue failures that resulted in titanium fires. The F/A-18 today can carry up to 17,000 lb of stores spread in nine stations, plus the M61 gun with 570 rounds in the fuselage nose. Air-to-surface modes use long-range mapping, with enhanced resolution by Doppler beam sharpening. Differing versions supplied to overseas forces are also described. Finally, some concepts that may prove to be competitive to the EFA and Rafale are offered. R.E.P.

A90-43765
MI-14 - THE SOVIET SEA KING
Air International (ISSN 0306-5634), vol. 38, May 1990, p. 230-235.
Copyright

The numerous versions of the amphibious Haze helicopter are presented along with its evolutionary development from the Mi-8 Hip transport helicopter. The basic airframe has the size and power to accommodate progressively improved sensors and weapons and has been adapted for mine counter-measures and search-and-rescue missions. Roughly equivalent to the SH-3 Sea King, the Haze first flew in 1973 using the same turboshaft engines dynamic components as the Hip and much of the structure. Advanced, higher thrust engines were introduced for the ASW version that was accompanied by provision of a more compact nacelle with shorter intakes and an improved gearbox, the tail rotor was transferred from the right side to the left side of the vertical stabiliser. Production over the last 15 years indicates that some 250 have been delivered and manufacturing still continues. R.E.P.

A90-43766
THE MCDONNELL DOUGLAS MD-11 . . . OR, HOW THE DC-10 GREW BIGGER
Air International (ISSN 0306-5634), vol. 38, June 1990, p. 277-286.
Copyright

The McDonnell Douglas role in the development and production of large capacity jetliners including the MD-11, derivative of and successor to the DC-10, is reviewed. Early studies and developmental work on USAF strategic freighter, long-range transport proposals, led to evolution of the jumbo-size commercial jetliner. Turbofan powered aircraft were the early contenders for these proposals, but the rapid advent of the straight jet powerplant soon became the prime power source for commercial aircraft application. From the inception of the original DC-10 through its

continuously improving versions, it is noted that the length of the fuselage was actually never stretched, as was that of its major competitors. Thus, the present MD-11 became the lengthened version of a new commercial jetliner. Operating at the same gross weight as the passenger version, freighter and combi derivatives of the same basic airframe are also offered. R.E.P.

A90-43767
DEMONSTRATING TECHNOLOGIES FOR ENHANCED FIGHTER MANOEUVERABILITY - THE ROCKWELL/MBB X-31
ROY BAYBROOK Air International (ISSN 0306-5634), vol. 38, June 1990, p. 287-294.
Copyright

The advanced concept, enhanced fighter maneuverability (EFM), is developing into a prime consideration in the proposed runoff of the advanced fighter program in the USA and design and development of the EFA and Rafale. EFM signifies the use of thrust vectoring for fighters during combat maneuvers, a method explored by AV-8 Harrier's during the course of their development and operational experiences. Investigations showed that the potential benefits in air combat of thrust vectoring, in terms of pitch-rate and g-increments, could be achieved with only small jet angles of deflection. For the X-31, the basic design approach is to improve effectiveness in close air combat by using enhanced fighter maneuverability without downgrading basic combat capability. As applied here, EFM combines six major features: enhanced conventional maneuverability, steep descent capability (for possible USN carrier approaches), poststall maneuverability, improved decoupled fuselage aiming, enhanced deceleration, and negative-g capability. R.E.P.

A90-43768
MIRAGE 2000 - A FRENCH SUCCESS THAT IS NO ILLUSION
PAUL JACKSON Air International (ISSN 0306-5634), vol. 38, March 1990, p. 111-121.
Copyright

A comprehensive review of the Dassault-Breguet Mirage 2000 evolution and experience to date is presented. At the present moment, this fighter aircraft has not only become a vital part of the French interceptor and tactical strike forces, but is also serving or on order with six foreign air forces. Various versions of this aircraft are described, including nuclear and nonnuclear armed variants as well as training types. Some details of the versions procured by foreign clients are discussed, and a complete detailed cutaway drawing of the Mirage 2000N is provided. R.E.P.

A90-43769
SUPPORT BACKBONE FOR THE SOVIET AIR FORCES . . . THE ILYUSHIN 'CANDID' FAMILY
Air International (ISSN 0306-5634), vol. 38, April 1990, p. 173-181, 209, 210.
Copyright

An evolutionary review of the Il-76 military and commercial transport from its inception in 1970 to its present role is presented. Comparative analysis throughout is made with the Lockheed C-141 transport as they compare closely in configuration, size and weight. The aircraft signified a major advance in Soviet design and manufacturing techniques and provided an important improvement for their military air transport logistical support capability. Currently, more than 400 examples are serving with the military and an additional 120-130 are used by commercial airlines and also serve as an available military reserve. In addition, export versions have been provided to a half-dozen countries. Though doubts as to the capabilities of this aircraft have been raised from time to time, it holds an impressive array of FAI-recognized international records for speed and altitude with payload, established before completion of the Il-76's flight development program. R.E.P.

A90-44223
CIVIL SUPERSONICS - A LESS DISTANT THUNDER
BILL SWEETMAN Interavia (ISSN 0020-6512), vol. 45, July 1990, p. 578, 579.
Copyright

Two U.S. companies are continuing the efforts of a small-scale 1987 NASA project on high-speed civil transport (HSCT) design which would reduce Los Angeles-Tokyo travel time from 10.3h to 4.3h. Considerations for cost, productivity, and a limited acceptance of supersonic boom have caused Boeing to focus on Mach numbers between 2.0 and 2.4 for overseas travel, and at Mach 0.9-1.1 for overland. Market projections have caused McDonnell Douglas to concentrate on low-boom designs to facilitate overland travel, while Boeing plans to target overseas routes where boom noise is more acceptable. Due to heating considerations, high-temperature thermoplastic resins and improved thermosetting matrixes are being considered for HSCT airframe construction. Landing and take-off noise are to be controlled by limiting the overall weight, by improving the low-speed aerodynamics, and by engine silencing. A naturally aspirated, coannular nozzle and an inverse coannular exhaust are discussed. L.K.S.

A90-44731*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IN-FLIGHT FLOW VISUALIZATION USING INFRARED IMAGING
J. M. BRANDON, G. S. MANUEL, R. E. WRIGHT, JR., and B. J. HOLMES (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 27, July 1990, p. 612-618. Previously cited in issue 17, p. 2778, Accession no. A88-42100. refs
Copyright

A90-44734#
OPTIMIZATION OF GLIDES FOR CONSTANT WIND FIELDS AND COURSE HEADINGS
SCOTT A. JENKINS and JOSEPH WASYL (California, University, La Jolla) Journal of Aircraft (ISSN 0021-8669), vol. 27, July 1990, p. 632-638. Research supported by the U.S. Navy. refs
Copyright

Theory and experiment are presented for optimal combinations of glide speeds and crab angles that minimize the glide slope at any arbitrary angle to the wind along a constant course heading. The optimization scheme is formulated for constant wind speeds, wind direction, and air mass sink rates. An analytic solution is found in the asymptotic limit of a small crosswind component. A general solution is obtained by seeded iterations with a Taylor series expansion about that limit. The solution was verified in test flights with quartering tailwinds and direct crosswinds at the 700, 500, and 300 mb levels. It was concluded that relatively small pilot-induced speed errors result in significant glide slope degradations with unnecessary and potentially dangerous altitude losses. Applications of the results are considered for wind fields that vary slowly in space, such as lee waves and Rossby waves. Author

A90-44736*# Lockheed Aeronautical Systems Co., Burbank, CA.
INTERIOR NOISE IN THE UNTREATED GULFSTREAM II PROPFAN TEST ASSESSMENT AIRCRAFT
H. L. KUNTZ and R. A. PRYDZ (Lockheed Aeronautical Systems Co., Burbank, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, July 1990, p. 647-652. Previously cited in issue 13, p. 1943, Accession no. A89-33754. refs
(Contract NAS3-24339)
Copyright

A90-44737*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PARAMETRIC AEROELASTIC STABILITY ANALYSIS OF A GENERIC X-WING AIRCRAFT
JESSICA A. WOODS, MICHAEL G. GILBERT (NASA, Langley Research Center, Hampton, VA), and TERRENCE A. WEISSHAAR (Purdue University, West Lafayette, IN) Journal of Aircraft (ISSN 0021-8669), vol. 27, July 1990, p. 653-659. Previously cited in issue 12, p. 1783, Accession no. A89-30858. refs
Copyright

A90-44738*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
DEVELOPMENT OF A REAL-TIME AEROPERFORMANCE ANALYSIS TECHNIQUE FOR THE X-29A ADVANCED TECHNICAL DEMONSTRATOR
RONALD J. RAY, JOHN W. HICKS (NASA, Flight Research Center, Edwards, CA), and RUSS I. ALEXANDER (Computing Devices Co., Ottawa, Canada) Journal of Aircraft (ISSN 0021-8669), vol. 27, July 1990, p. 660-667. Previously cited in issue 15, p. 2404, Accession no. A88-38738. refs
Copyright

A90-44751
DORNIER COMPOSITE AIRCRAFT - ECONOMICAL AND FAULTLESS [DORNIER COMPOSITE AIRCRAFT - PREISWERT UND TADELLOS]
ARNT EBERHARDT Luft- und Raumfahrt (ISSN 0173-6264), vol. 11, 2nd Quarter, 1990, p. 20, 22, 23. In German.
Copyright
The temperature optimization of composites for aircraft components is discussed. Emphasis is given to thermoanalysis using differential scanning calorimetry. The Dornier Seastar aircraft is examined as an example of the application of this composite technology. C.D.

A90-44781#
SUPERSONIC STOVL - THE FUTURE IS NOW
DANIEL P. RAYMER, Y. T. CHIN, YALE F. KIEFER, KENNETH J. HAJIC, and JOHN L. BENSON (Lockheed Aeronautical Systems Co., Burbank, CA) Aerospace America (ISSN 0740-722X), vol. 28, Aug. 1990, p. 18-22, 28.
Copyright
Technologies and concepts essential to construction of the first practical Western supersonic fighter with STOVL capability are examined. Early STOVL technology is discussed, and it is noted that the Harrier aircraft has been limited to transonic speeds because its supersonic drag is too high. Requirements for new STOVL capabilities are considered. Top speed should be above Mach 1.6 and the aircraft should reach supersonic flight without using its afterburner. New technologies in propulsion, materials, and controls have made such a STOVL feasible; however, the right mix of speed, range, payload, maneuvering and performance, avionics, and operating environment needed to produce an affordable aircraft remain to be found. Lockheed has focused its approaches to supersonic STOVL design on three propulsion and configuration concepts: the split flow in hover (SFIH) concept, the shaft-driven lift fan (SDLF) concept, and the reverse-installation vectored engine thrust (RIVET) concepts. L.K.S.

A90-45425
DOUGLAS AGING AIRCRAFT PROGRAMS
JEAN A. MCGREW and AMOS W. HOGGARD (Douglas Aircraft Co., Long Beach, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 15 p.
(SAE PAPER 892206) Copyright
Modern design practices for long-life aircraft and how they relate to the current aging aircraft fleet situation are presented. Concepts of the maintenance programs are also introduced along with means of modifying the program to protect the aircraft against the increased probability of fatigue and corrosion as the aircraft ages. Special programs by the manufacturer, such as extended fatigue testing and on-site aircraft evaluations, are discussed. The recent aging aircraft activities sponsored by the ATA and AIA are also examined. Author

A90-45427
MAINTENANCE AND ECONOMIC BENEFITS OF NON-PAINTED AIRCRAFT OPERATIONS
DELL F. SKLUZAK (Aluminum Company of America, Davenport, IA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 10 p. refs
(SAE PAPER 892208) Copyright
Alclad aluminum sheet has been used for decades as the material of choice for aircraft fuselage sheet. Producers have developed and improved aluminum alloys that today allow airline companies to fly polished unpainted aircraft that are attractive, unique and instantly identifiable to the traveling public. The use of polished fuselages not only provides an attractive exterior but also offers functional benefits. These include fuel savings by flying with less paint, maintenance savings from refuced down time during C and D checks, reduction in hazardous waste disposal, and improved inspection capabilities. Arguments for both sides of this issue are sound. However, the proven advantages of flying non-painted polished aircraft necessitate consideration of the concept of flying non-painted polished fleets for improved economic performance. Author

A90-45429
DESIGN AND CERTIFICATION OF THE ALL-COMPOSITE AIRFRAME
RIC ABBOTT (Beech Aircraft Corp., Wichita, KS) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 10 p. refs
(SAE PAPER 892210) Copyright
The Starship business aircraft has a maximum takeoff weight of 14,500 lbs; of its empty weight of 9511 lbs, about 4000 is structural, and of that over 2700 lbs is made up of advanced composites. The carbon-epoxy components of this composite structure constitute 1850 lbs. Attention is presently given to the criteria for material and structural certification applied to the Starship, as well as to the damage tolerance characteristics of these adhesively bonded components. While the composites employed yield a maximum design stress at ultimate load of 60,000 psi, the figure for a comparable aluminum alloy structure is only about 45,000 psi. In addition, graphite-epoxy composites are only 57 percent as dense as aluminum alloy. O.C.

A90-45431
CATALYTIC CONVERSION OF OIL IN BLEED AIR - A MAINTENANCE TOOL
THOMAS A. DICKEY (Textron Lycoming, Stratford, CT) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 6 p.
(SAE PAPER 892214) Copyright
To protect the air conditioning system of a turbine powered aircraft from contamination by traces of oil in the air bled from main engines and APU, a catalytic converter was developed for each, and put in service in the British Aerospace 146. The development procedures and flight hardware are described, data for sizing and pressure drop are presented, and limited service experience outlined. Author

A90-45447
FLIGHT DECK MODERNIZATION
GERALD STONE, NOREEN STODOLSKY, and THOMAS P. JAHN (Douglas Aircraft Co., Long Beach, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 10 p. refs
(SAE PAPER 892231) Copyright
This paper demonstrates how the flight deck of a derivative aircraft was optimized within the rigid constraints of existing structure, avionics, and performance features. The new design effort utilized three-dimensional computer modeling, combined with iterative, interdisciplinary decision-making. The feasibility of design recommendations made by the interdisciplinary team was analyzed using three-dimensional and solid models of flight compartment interiors and humans. Visual, anthropometric, and comfort considerations were assessed using the McDonnell Douglas Computer-Aided Design and Drafting (CADD) system. AITOFF and perspective projection capabilities were utilized to generate external and internal vision envelopes. The CADD system also hosted a number of computerized human modeling techniques including Crew Station Assessment of reach (CAR), Articulated Total Body Model (ATBM), a computerized reach envelope, and Touch-and-Draw. Author

A90-45448* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
OVERVIEW OF MILITARY TECHNOLOGY AT NASA LANGLEY
WALLACE C. SAWYER and CHARLIE M. JACKSON, JR. (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 12 p. refs
(SAE PAPER 892232) Copyright

The Langley Research Center began addressing major research topics pertinent to the design of military aircraft under the egis of The National Advisory Council on Aeronautics in 1917, until 1958, when it passed under the control of the newly-instituted NASA research facilities system. A historical account is presented of NASA-Langley's involvement in the experimental investigation of twin-engined jet aircraft nozzle interfairings, thrust reversers, high-efficiency supersonic cruise configurations, high-alpha aerodynamics, air-to-air combat handling qualities, wing/stores flutter suppression, and store carriage and separation characteristics. O.C.

A90-45449* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PROPULSION INTEGRATION FOR MILITARY AIRCRAFT
WILLIAM P. HENDERSON (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 15 p. refs
(SAE PAPER 892234) Copyright

The transonic aerodynamic characteristics for high-performance aircraft are significantly affected by shock-induced flow interactions as well as other local flow interference effects which usually occur at transonic speeds. These adverse interactions can not only cause high drag, but can cause unusual aerodynamic loadings and/or severe stability and control problems. Many new programs are underway to develop methods for reducing the adverse effects, as well as to develop an understanding of the basic flow conditions which are the primary contributors. It is anticipated that these new programs will result in technologies which can reduce the aircraft cruise drag through improved integration as well as increased aircraft maneuverability throughh the application of thrust vectoring. This paper will identify some of the primary propulsion integration problems for high performance aircraft at transonic speeds, and demonstrate several methods for reducing or eliminating the undesirable characteristics, while enhancing configuration effectiveness. Author

A90-45450
INITIAL SERVICE EXPERIENCE WITH THE FOKKER 100
H. AMMANN (Swissair, Zurich, Switzerland) and A. VAN DER SCHRAAF (Fokker Aircraft, Amsterdam, Netherlands) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 5 p.
(SAE PAPER 892238) Copyright

The paper outlines the behavior of the Fokker 100 during its first year of commercial service with Swissair, the launch customer. Main design features are briefly discussed, together with selection criteria which prompted Swissair to become launch customer. Some aspects of crew training in relation to the introduction of glass cockpits are highlighted. Author

A90-45458
ROTARY SERVOHINGE ACTUATOR
GEORGE MILLER, JR. and MARK WILLIAMS (HR Textron, Inc., Valencia, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 15 p.
(SAE PAPER 892261) Copyright

Thin-wings impose a unique combination of demanding requirements on a primary control-surface servoactuator. To address these requirements, a rotary servohinge actuator has been developed by HR Textron Inc. (HR). It uses a large lead-angle, recirculating ballscrew to convert linear motion of a conventional hydraulic actuator to rotary motion. This paper describes the thin-wing problem in detail, explains the rationale for selecting the adopted design, and discusses the actuator design and development program. A summary of servohinge performance and progress of the test program also is provided. The servohinge and electronic controller were delivered to the McDonnell Aircraft Company in support of the WRDC (USAF)-sponsored Advanced Development Program (ADP). Author

A90-45459
LIGHTWEIGHT, COMPOSITE FLIGHT CONTROL ACTUATORS
FRED CHING (HR Textron, Inc., Valencia, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 16 p.
(SAE PAPER 892264) Copyright

The development of composite actuators/components for airborne systems has demonstrated up to 47 percent weight savings as compared to conventional (metal) actuators. In addition, the composite actuator is 'jam resistant', satisfying a survivability requirement for the Navy. Current composite actuators have passed or exceeded all critical tests (proof, impulse and life cycling, temperature shock, vibraiton, burst) based on a high performance aircraft specification (F/A-18). Author

A90-45491
TITANIUM MATRIX COMPOSITE LANDING GEAR DEVELOPMENT
WILLIAM W. MACY, MARK A. SHEA (McDonnell Douglas Corp., Saint Louis, MO), and DAVID L. MORRIS (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 10 p.
(SAE PAPER 892337) Copyright

Design and fabrication of a titanium matrix composite (TMC) F-15 nose landing gear (NLG) outer cylinder is discussed. Results of a field experience survey examining landing gear (LG) operations are also discussed. Weight, supportability and cost benefits are summarized for this component and projected for production applications of the material. Author

A90-45500
EVALUATION OF CRITICAL SPEEDS IN HIGH SPEED AIRCRAFT TIRES
JOE PADOVAN, AMIR KAZEMPOUR (Akron, University, OH), FARHAD TABADDOR (Uniroyal Goodrich Corp., Akron, OH), and BOB BROCKMAN (Dayton, University, OH) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 12 p. refs
(SAE PAPER 892349) Copyright

By recasting the rolling tire system as a large deformation nonlinear eigenvalue problem, this paper develops a methodology capable of handling the critical speed/standing wave response. Based on a moderate/small deformation superposed on large finite element formulation, tangent properties are developed to enable the establishment of the appropriate critical speed eigenvalue problem. The methodology enables the handling of large deformation kinematics material nonlinearity, rotational inertial fields, as well as contact boundary conditions. Employing the model, the results of a benchmark example involving the NASA space shuttle main tires are presented. This includes evaluating the effects of rotation, material stiffness, pressurization and large deformation contact on the critical speed properties. Author

A90-45501* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FRICTIONLESS CONTACT OF AIRCRAFT TIRES
KYUN O. KIM, JOHN A. TANNER, and AHMED K. NOOR (NASA, Langley Research Center; George Washington University, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 18 p. refs
(SAE PAPER 892350) Copyright

A computational procedure for the solution of frictionless contact problems of spacecraft tires was developed using a two-dimensional laminated anisotropic shell theory incorporating the effects of variations in material and geometric parameters, transverse shear deformation, and geometric nonlinearities to

model the nose-gear tire of a space shuttle. Numerical results are presented for the case when the nose-gear tire is subjected to inflation pressure and pressed against a rigid pavement. The results are compared with experimental results obtained at NASA Langley, demonstrating a high accuracy of the model and the effectiveness of the computational procedure. I.S.

A90-45502 Texas A&M Univ., College Station.
AIRCRAFT TIRE/PAVEMENT PRESSURE DISTRIBUTIONS
JOHN T. TIELKING (Texas A & M University, College Station) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 10 p. Research supported by NASA and USAF. refs
(SAE PAPER 892351) Copyright

A finite element tire model has been used to examine pavement pressure distributions developed by statically loaded aircraft tires. This paper briefly describes the tire model's characteristics and presents load versus deflection curves and pavement pressure distributions calculated for three different aircraft tires. The tire model shows that the nonuniformity of the tire/pavement pressure distribution increases when the tire is operated at an inflation pressure or tire load that is above or below the design value for that tire. The data calculated by the tire model are compared with load-deflection curves and contact pressure data measured for the tires modeled. Author

N90-25092# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.). Unternehmensgruppe Hubschrauber und Flugzeuge.
SCENARIO 2000 [SZENARIO 2000]
VOLKER VONTEIN *In its* Research and Development: Technical and Scientific Publications 1989 p 161-170 1989 In GERMAN Presented at Hubschrauberforum, Bueckeburg, Fed. Republic of Germany, 9-10 May 1989
(MBB-UD-500/89-PUB) Avail: NTIS HC A15/MF A02

Helicopter programs of the near future are presented. It is predicted that the European military needs must be more important if the European manufactures are to survive. Interesting markets can be found in China or India. The helicopters are more often used as rescue vehicles or police vehicles in Germany, Japan, England or Holland. International cooperation and combination of military and civilian programs are absolutely necessary in future years. ESA

N90-25125# Naval Postgraduate School, Monterey, CA.
AN APPROACH FOR DESIGN AND ANALYSIS OF COMPOSITE ROTOR BLADES M.S. Thesis
GERALDO A. MACEDOMOURA Sep. 1989 87 p
(AD-A219257) Avail: NTIS HC A05/MF A01 CSCL 01/3

The advent of tilt rotor technology asks for rotors that have different twist and RPM requirements in hover and in forward flight to optimize for operational conditions. In order to get an assessment of the capabilities to fulfill these requirements this report presents a mapping of twist angle variation as a function of RPM and laminate orientation. The basic laminate for the six models as well the D-shape spar that represents the structurally active part of the blade is assumed to be constant. This six layer cross ply laminate is chosen as it provides the necessary extension-twist coupling without a hygrothermally induced twist that is highly undesireable. The couplings and trends in the models are visualized in carpet plots, one for each model, in an attempt to establish a method to answer the basic question of the magnitude of twist angle available due to a particular geometry, material and load system. GRA

N90-25126*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
TIME-OPTIMAL AIRCRAFT PURSUIT-EVASION WITH A WEAPON ENVELOPE CONSTRAINT Final Report
P. K. A. MENON Jun. 1990 24 p Presented at the American Control Conference, San Diego, CA, 23-25 May 1990
(Contract NCC2-506)
(NASA-CR-186640; NAS 1.26:186640) Avail: NTIS HC A03/MF A01 CSCL 01/3

The optimal pursuit-evasion problem between two aircraft including a realistic weapon envelope is analyzed using differential game theory. Six order nonlinear point mass vehicle models are employed and the inclusion of an arbitrary weapon envelope geometry is allowed. The performance index is a linear combination of flight time and the square of the vehicle acceleration. Closed form solution to this high-order differential game is then obtained using feedback linearization. The solution is in the form of a feedback guidance law together with a quartic polynomial for time-to-go. Due to its modest computational requirements, this nonlinear guidance law is useful for on-board real-time implementation. Author

N90-25127*# Notre Dame Univ., IN. Dept. of Aerospace and Mechanical Engineering.
THE STEALTH BIPLANE: A PROPOSAL IN RESPONSE TO A LOW REYNOLDS NUMBER STATION KEEPING MISSION Final Design Proposal
TIMOTHY E. WALSH, KEVIN T. FLYNN, STEVEN DONOVAN, CHRIS PAUL, HAROLD PANGILINAN, JOHN PADGETT, and DANIEL TWOMEY May 1990 100 p
(Contract NASW-4435)
(NASA-CR-186680; NAS 1.26:186680) Avail: NTIS HC A05/MF A01 CSCL 01/3

The Stealth Biplane is conceived and constructed to serve as a remotely piloted vehicle designed to navigate a low-level figure-eight course at a target Reynolds number of 100,000. This flight vehicle will combine the latest in lightweight radio controlled hardware in conjunction with current low Reynolds number aerodynamic research to demonstrate feasible operation in a variety of applications. These potential low Reynolds number applications include high altitude atmospheric sampling, search and rescue, and even law enforcement. Design specs and fabrication technique are discussed. Author

N90-25132*# *Auburn Univ., AL.*
DESIGN OF A LOW COST SHORT TAKEOFF-VERTICAL LANDING EXPORT FIGHTER/ATTACK AIRCRAFT
ANNE BELCHER, DAN BODEKER, III, STEVE MIU, LAURA PETRO, CARY TAYLOR SENF, and DONALD WOELTJEN Jun. 1990 91 p
(Contract NASW-4435)
(NASA-CR-186658; NAS 1.26:186658) Avail: NTIS HC A05/MF A01 CSCL 01/3

The design of a supersonic short takeoff and vertical landing (STOVL) aircraft is presented that is suitable for export. An advanced four poster, low bypass turbofan engine is to be used for propulsion. Preliminary aerodynamic analysis is presented covering a determination of CD versus CL, CD versus Mach number, as well as best cruise Mach number and altitude. Component locations are presented and center of gravity determined. Cost minimization is achieved through the use of developed subsystems and standard fabrication techniques using nonexotic materials. Conclusions regarding the viability of the STOVL design are presented. Author

N90-25133# Wichita State Univ., KS. Inst. for Aviation Research.
ELEVATOR TAB ASSEMBLY PRODUCIBILITY STUDY
WAYNE BECKER, MARK WADSWORTH, and DARRIN TEETER Jul. 1989 86 p
(IAR-89-16) Avail: NTIS HC A05/MF A01

In November 1988, Beech Aircraft Corp. requested a producibility study of resin transfer molding (RTM) for aircraft structures. Specifically, the technology was to be developed which would enable Beech to manufacture a composite elevator trim tab more cost effectively and with more structural efficiency than is presently possible. Appendix C contains the proposal and previous designs that have been made. The results of this research are summarized. Author

N90-25134*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
EVALUATION OF VARIOUS THRUST CALCULATION TECHNIQUES ON AN F404 ENGINE
RONALD J. RAY Apr. 1990 31 p
(NASA-TP-3001; H-1505; NAS 1.60:3001) Avail: NTIS HC A03/MF A01 CSCL 21/5

In support of performance testing of the X-29A aircraft at the NASA-Ames, various thrust calculation techniques were developed and evaluated for use on the F404-GE-400 engine. The engine was thrust calibrated at NASA-Lewis. Results from these tests were used to correct the manufacturer's in-flight thrust program to more accurately calculate thrust for the specific test engine. Data from these tests were also used to develop an independent, simplified thrust calculation technique for real-time thrust calculation. Comparisons were also made to thrust values predicted by the engine specification model. Results indicate uninstalled gross thrust accuracies on the order of 1 to 4 percent for the various in-flight thrust methods. The various thrust calculations are described and their usage, uncertainty, and measured accuracies are explained. In addition, the advantages of a real-time thrust algorithm for flight test use and the importance of an accurate thrust calculation to the aircraft performance analysis are described. Finally, actual data obtained from flight test are presented.
Author

N90-25135*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLUTTER CLEARANCE OF THE F-14A VARIABLE-SWEEP TRANSITION FLIGHT EXPERIMENT AIRPLANE, PHASE 2
LAWRENCE C. FREUDINGER and MICHAEL W. KEHOE Jul. 1990 43 p
(NASA-TM-101717; H-1544; NAS 1.15:101717) Avail: NTIS HC A03/MF A01 CSCL 01/3

An F-14A aircraft was modified for use as the test-bed aircraft for the variable-sweep transition flight experiment (VSTFE) program. The VSTFE program was a laminar flow research program designed to measure the effects of wing sweep on laminar flow. The airplane was modified by adding an upper surface foam and fiberglass glove to the right wing. An existing left wing glove had been added for the previous phase of the program. Ground vibration and flight flutter testing were accomplished to verify the absence of aeroelastic instabilities within a flight envelope of Mach 0.9 or 450 knots, calibrated airspeed, whichever was less. Flight test data indicated satisfactory damping levels and trends for the elastic structural modes of the airplane. Ground vibration test data are presented along with in-flight frequency and damping estimates, time histories and power spectral densities of in-flight sensors, and pressure distribution data.
Author

N90-25136# Federal Aviation Administration, Atlantic City, NJ.
THE EFFECT OF AIRCRAFT SIZE ON CABIN FLOOR DYNAMIC PULSES Final Report, Oct. 1987 - Dec. 1989
GIL WITTLIN (Lockheed Aeronautical Systems Co., Burbank, CA.) and LARRY NERI Mar. 1990 60 p
(Contract DTFA03-84-C-00004)
(DOT/FAA/CT-88/15; LR-31426) Avail: NTIS HC A04/MF A01

Size scaling trends are reviewed and updated. An investigation is presented into the effect that airplane size has on dynamic floor pulses generated within the cabin during a crash impact event. Included is: (1) A review of narrow-body and wide-body section test results and supporting analytical model results; (2) The utilization of the Controlled Impact Demonstration (CID) validated KRASH model to perform additional parametric studies; (3) Defined relationships between parameters which influence aircraft structure dynamic response; and (4) Developed airplane preliminary size effect trend curves for floor dynamic pulses in terms of triangular pulse magnitudes, velocity changes and pulse duration. A simple approximate expression relating aircraft fuselage crush energy dissipation and kinetic energy are utilized to generate a set of triangular pulse velocity - crush distance - peak acceleration curves. Estimated effective crush distances for various classes of airplane sizes or categories and available acceleration, velocity and crush data are plotted. Plots for vertical-direction and longitudinal-direction are presented.
Author

N90-25137# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.). Dienstleistungsbereich.
CALCULATION OF THICK WALL FIBER BINDERS FOR ROTOR COMPONENTS OF MODERN HELICOPTERS [BERECHNUNG DICKWANDIGER FASERVERBUNDE FUER ROTORKOMPONENTEN MODERNER HUBSCHRAUBER]
O. HAIDER 1989 22 p In GERMAN Presented at DGLR-Jahrestagung-1989, Hamburg, Fed. Republic of Germany, 2-4 Oct. 1989
(MBB-UD-554/84-PUB; DGLR-89-127; ETN-90-96779) Avail: NTIS HC A03/MF A01

The fiber binder structure is calculated by the finite element method to obtain the characteristic values of dimensional elasticity. An extension of the laminate theory is made to determine complete elasticity constants. It is then possible to gather several laminate layers in a material. It is unnecessary to idealize separately every layer, which reduces greatly the calculation time. A good shape of elements of a helicopter rotor was found with this method.
ESA

N90-25966*# Douglas Aircraft Co., Inc., Long Beach, CA. New Commercial Programs.
STUDY OF HIGH-SPEED CIVIL TRANSPORTS. SUMMARY Final Report
Washington NASA Aug. 1990 53 p
(Contract NAS1-18378)
(NASA-CR-4236; NAS 1.26:4236) Avail: NTIS HC A04/MF A01 CSCL 01/3

A systems study to identify the economic potential for a high-speed commercial transport has considered technology, market characteristics, airport infrastructure, and environmental issues. Market forecasts indicate a need for high speed civil transport (HSCT) service in the 2000/2010 time frame conditioned on economic viability and environmental acceptability. Design requirements focused on a 300 passenger, 3 class service, and 6500 nautical mile range based on the accelerated growth of the Pacific region. Compatibility with existing airports was an assumed requirement. Mach numbers between 2 and 25 were examined in conjunction with the appropriate propulsion systems, fuels, structural materials, and thermal management systems. Aircraft productivity was a key parameter with aircraft worth, in comparison to aircraft price, being the airline-oriented figure of merit. Aircraft screening led to determination that Mach 3.2 (TSJF) would have superior characteristics to Mach 5.0 (LNG) and the recommendation that the next generation high-speed commercial transport aircraft use a kerosene fuel. The sensitivity of aircraft performance and economics to environmental constraints (e.g., sonic boom, engine emissions, and airport/community noise) was identified together with key technologies. In all, current technology is not adequate to produce viable HSCTs for the world marketplace. Specific technology requirements have been identified which was the prime objective of this study. National economic benefits are projected.
Author

N90-25967*# Worcester Polytechnic Inst., MA.
FEASIBILITY STUDY FOR A MICROWAVE-POWERED OZONE SNIFFER AIRCRAFT, VOLUME 2
1990 203 p
(Contract NASW-4435)
(NASA-CR-186676; NAS 1.26:186676) Avail: NTIS HC A10/MF A02 CSCL 01/3

Using 3-D design techniques and the Advanced Surface Design Software on the Computervision Designer V-X Interactive Graphics System, the aircraft configuration was created. The canard, tail, vertical tail, and main wing were created on the system using Wing Generator, a Computervision based program introduced in Appendix A.2. The individual components of the plane were created separately and were later individually imported to the master

database. An isometric view of the final configuration is presented. Author

N90-25969# Wichita State Univ., KS. Inst. for Aviation Research.
A NASA/UNIVERSITY/INDUSTRY CONSORTIUM FOR RESEARCH ON AIRCRAFT ICE PROTECTION
GLEN W. ZUMWALT Oct. 1989 9 p Presented at the 24th Annual Midwest Regional Conference, Wichita, KS, 22-24 Mar. 1989
(IAR-89-18) Avail: NTIS HC A02/MF A01

From 1982 through 1987, an unique consortium was functioning which involved government (NASA), academia (Wichita State Univ.) and twelve industries. The purpose was the development of a better ice protection systems for aircraft. The circumstances which brought about this activity are described, the formation and operation recounted, and the effectiveness of the ventue evaluated. Author

N90-25971*# California State Polytechnic Univ., Pomona.
GLOBAL SENTRY: NASA/USRA HIGH ALTITUDE RECONNAISSANCE AIRCRAFT DESIGN, VOLUME 2
MONA-LISA ALEXANDRU, FRANK MARTINEZ, JIM TSOU, HENRY DO, ASHISH PETERS, TOM CHATSWORTH, YE YU, and JASKIRAN DHILLON 1990 119 p
(Contract NGT-21-002-800)
(NASA-CR-186820-VOL-2; NAS 1.26:186820-VOL-2; ARO-446; ARO-463) Avail: NTIS HC A06/MF A01 CSCL 01/3

The Global Sentry is a high altitude reconnaissance aircraft design for the NASA/USRA design project. The Global Sentry uses proven technologies, light-weight composites, and meets the R.F.P. requirements. The mission requirements for the Global Sentry are described. The configuration option is discussed and a description of the final design is given. Preliminary sizing analyses and the mass properties of the design are presented. The aerodynamic features of the Global Sentry are described along with the stability and control characteristics designed into the flight control system. The performance characteristics are discussed as is the propulsion installation and system layout. The Global Sentry structural design is examined, including a wing structural analysis. The cockpit, controls and display layouts are covered. Manufacturing is covered and the life cost estimation. Reliability is discussed. Conclusions about the current Global Sentry design are presented, along with suggested areas for future engineering work. Author

N90-25972*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SYNTHESIS OF INDIVIDUAL ROTOR BLADE CONTROL SYSTEM FOR GUST ALLEVIATION Final Report
JI C. WANG, ALPHONSE Y. CHU (San Jose State Univ., CA.), and PETER D. TALBOT Jul. 1990 72 p
(Contract NCC2-267)
(NASA-TM-101886; NAS 1.15:101886) Avail: NTIS HC A04/MF A01 CSCL 01/3

The utilization of rotor flapping in synthesizing an Individual Blade Control (IBC) system for gust alleviation is demonstrated. The objective is to illustrate and seek to improve Ham's IBC method. A sensor arrangement with two accelerometers mounted on the root and tip of a blade is proposed for estimating of flapping states for feedback control. Equivalent swash plate implementation of IBC is also deliberated. The study concludes by addressing the concept of general rotor states feedback, of which the IBC method is a special case. The blade flapping equation of motion is derived. Ham's original IBC method and a modified IBC scheme called Model Reference (MRIBC) are examined, followed by simulation study with ideal measurements and relative performances of the two methods. The practical aspects of IBC implementation are presented. Different configuration of sensors and their merits are considered. The realization of IBC using equivalent swash plate instead of direct actuator motion is discussed. It is shown that IBC is a particular case of rotor states feedback. The idea of general rotor states feedback is further elaborated. Finally, major conclusions are given. Author

N90-25973*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
AN IN-FLIGHT INTERACTION OF THE X-29A CANARD AND FLIGHT CONTROL SYSTEM
MICHAEL W. KEHOE, LISA J. BJARKE, and EDWARD J. LAURIE (Grumman Aerospace Corp., Bethpage, NY.) Apr. 1990 21 p Presented at the AIAA Dynamics Specialists Meeting, Long Beach, CA, 5-6 Apr. 1990
(NASA-TM-101718; H-1590; NAS 1.15:101718) Avail: NTIS HC A03/MF A01 CSCL 01/3

Many of today's high performance airplanes use high gain, digital flight control systems. These sytems are liable to couple with the aircraft's structural dynamics and aerodynamics to cause an aeroservoelastic interaction. These interactions can be stable or unstable depending upon damping and phase relationships within the system. The details of an aeroservoelastic interaction experienced in flight by the X-29A forward-swept wing airplane. A 26.5-Hz canard pitch mode response was aliased by the digital sampling rate in the canard position feedback loop of the flight control system, resulting in a 13.5-Hz signal being commanded to the longitudinal control surfaces. The amplitude of this commanded signal increased as the wear of the canard seals increased, as the feedback path gains were increased, and as the canard aerodynamic loading decreased. The resultant control surface deflections were of sufficient amplitude to excite the structure. The flight data presented shows the effect of each component (structural dynamics, aerodynamics, and flight control system) for this aeroservoelastic interaction. Author

N90-25974# Technische Univ., Brunswick (Germany, F.R.). Fakultaet fuer Maschinenbau und Elektrotechnik.
A CONTRIBUTION TO THE IMPROVEMENT OF THE ACCURACY IN THE PARAMETER IDENTIFICATION OF NONLINEAR PROCESSES, BY EXAMPLE OF THE AIRCRAFT MOTION Ph.D. Thesis [EIN BEITRAG ZUR GENAUIGKEITSSTEIGERUNG BEI DER PARAMETERIDENTIFIZIERUNG NICHTLINEARER PROZESSE AM BEISPIEL DER FLUGZEUBEWEGUNG]
KARL-OSKAR PROSKAWETZ 1989 157 p In GERMAN
(ETN-90-96961) Avail: NTIS HC A08/MF A01

The parameter identification of nonlinear dynamic processes was studied taking by example the aircraft motion of the double motor research aircraft Dornier DO-28. A two-step maximum likehood output error method was developed as identification method. The first step uses the exactly known, kinematic correlations between the flight situation quantities to check the consistency of the measured data and allows estimation of the necessary corrections. In the second step an iterative nonlinear multipoint model was used to describe more exactly the local aerodynamic interferences. The results demonstrate the general applicability and efficiency of modern offline identification methods for parameter estimation of nonlinear dynamic processes. ESA

N90-25975# Technische Univ., Brunswick (Germany, F.R.). Fakultaet fuer Maschinenbau und Elektrotechnik..
THE APPLICABILITY OF SIMPLE HELICOPTER MODELS FOR FLIGHT MECHANICS STUDIES Ph.D. Thesis [DIE ANWENDBARKEIT EINFACHER HUBSCHRAUBERMODELLE FUER FLUGMECHANISCHE UNTERSUCHUNGEN]
KARL LIESE 1989 166 p In GERMAN Sponsored by BMFT
(ETN-90-96962) Avail: NTIS HC A08/MF A01

Helicopter mathematical models of different complexity were developed for the multitude of flight-mechanical questions, and their application domain were determined. A simple model was developed that is representative of rotor dynamics, rotor blades impact motion as well as dynamic rotor flow. Starting from this model, simplified models of different complexity were generated. The model results show good agreement with those of other calculation methods and with flight test data. It is shown that a

helicopter modeling with simplified rotor dynamics as a first order system covers a significantly broader frequency range than quasistationary methods. However, the applicability of rigid body models to control problems is questionable. ESA

N90-25976# Stuttgart Univ. (Germany, F.R.). Inst. fuer Computer-Anwendungen.
A CONTRIBUTION TO THE ECONOMIC, OPTIMAL DIMENSIONING, AND SHAPING OF AIRCRAFT STRUCTURES USING A DESIGN MODEL Ph.D. Thesis [EIN BEITRAG ZUR OEKONOMISCHEN, OPTIMALEN DIMENSIONIERUNG UND FORMGEBUNG ALLGEMEINER TRAGWERKE MIT HILFE EINES ENTWURFSMODELLS]
PETER SCHMOLZ 1988 210 p In GERMAN
(ETN-90-96966) Avail: NTIS HC A10/MF A02

A method for the optimization of dimensions and shape of aircraft structures is presented. As target function for minimization the weight and the maximum stress can be chosen. The reduction of the optimization variables requires an optimization data structure independent of the finite element structure. The structure is divided into optimization substructures and design elements. Interpolation approaches are used in the dimension optimization to approximate the geometric data. For the shape optimization several imaging functions are used. A method for the economic calculation of the required re-analysis was deduced. The optimization concept is demonstrated by examples. ESA

N90-25977# Rolls-Royce Ltd., Derby (England).
STAGE 2 RE-ENGINING: THE ONLY WAY TO ACHIEVE A REAL STAGE 3 AIRCRAFT
M. J. T. SMITH and K. GODDARD 3 Nov. 1989 11 p Presented at the Royal Aeronautical Society Conference on Aircraft Ageing and Noise Problems: Consequences for the Aviation Industry, London, England, 3 Nov. 1989; sponsored by FFV Aerotech, Sweden
(PNR90636; ETN-90-97143) Copyright Avail: NTIS HC A03/MF A01

The re-engining of the Rolls-Royce Tay is discussed. Airport authorities in the U.S. and Europe insist that only stage 3 compliant aircraft are able to operate at night. The impact of this, and technical options available to make stage 2 aircraft meet stage 3 standards are considered. Noise reduction possibilities and hushkits are described. The Tay 650 and 670 engines are described and illustrated. Other benefits of re-engining are discussed. ESA

N90-25978# Costruzioni Aeronautiche Giovanni Agusta S.p.A., Cascina Costa (Italy). Div. Elicotteri.
AGUSTA METHODOLOGY FOR PITCH LINK LOADS PREDICTION IN PRELIMINARY DESIGN PHASE
FABIO NANNONI and ALESSANDRO STABELLINI 20 Sep. 1988 54 p In ENGLISH and ITALIAN Presented at 14th European Rotorcraft Forum, Milan, Italy, 20-23 Sep. 1988 Previously announced in IAA as A90-42465
(ETN-90-97270) Avail: NTIS HC A04/MF A01

The fast increase of static and torsional loads at the root of the blade is, sometimes, the first limit that a helicopter meets in forward flight at high speed. A good design must consider an analysis of this phenomenon which is very important in rotation control development and, above all, in performance estimation and handling qualities of the whole aircraft. The Agusta methodology for the estimation of these loads in the preliminary design is presented. ESA

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A90-43376* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AIRBORNE MSS FOR LAND COVER CLASSIFICATION II
PAUL J. CURRAN (NASA, Ames Research Center, Moffett Field, CA; Swansea, University College, Wales) and MIKE I. PEDLEY (Sheffield, University, England) Geocarto International (ISSN 1010-6049), vol. 5, June 1990, p. 15-26. refs
Copyright

A basic methodology for land cover classification using airborne multispectral scanner (MSS) imagery is outlined. This includes waveband selection and radiometric calibration; correction for scan angle and atmosphere; training and classification and accuracy assessment. Refinements to this basic methodology include per-field sampling and the addition of low-pass filtering, image texture, prior probabilities and two dates of imagery. For a study area in upland England, eight land covers were classified with a mean accuracy of 52.6 percent using the basic methodology. This was increased to 79.0 percent by using a suitability refined methodology. Per-field sampling accounted for the largest proportion of this increase. Author

A90-43727
CORRELATION BETWEEN VIBRATION AND COMPUTER OPERATOR RESPONSE ONBOARD A UH-1H HELICOPTER
GEORGE O. WHITE (U.S. Army, Combat Systems Test Activity, Aberdeen Proving Ground, MD) IN: Institute of Environmental Sciences, Annual Technical Meeting, 35th, Anaheim, CA, May 1-5, 1989, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1989, p. 18-23. refs
Copyright

The possibility of a correlation between helicopter vibration and onboard computer operator response was investigated by measuring acceleration data on two computer displays and two seat pads aboard the UH-1H helicopter. Two types of ride quality analysis were performed on the data from the seat pad locations, and linear-regression and rank-correlation analyses were performed to correlate operator mean input time with the various types of acceleration data. No apparent relationship emerges between the onboard computer operator response and the acceleration of the computer displays, or of the ride quality measured on the computer operators' helicopter seats. O.C.

A90-44722
DIGITAL SERVOMECHANISM FOR THE TACHOMETER OF THE M 602 ENGINE [CISLICOVY SERVOMECHANISMUS PRO OTACKOMERY MOTORU M 602]
PAVEL KROTIL Zpravodaj VZLU (ISSN 0044-5355), no. 2, 1990, p. 77-83. In Czech.
Copyright

The design of the electronic tachometer of the M 602 engine of the L610 aircraft is described. The device is designed as a digital positional servomechanism; the control electronics is purely digital. B.J.

A90-45239
CHARACTERISTICS OF 5X5 AND 6X6 INCH TAUT SHADOW MASK CRTS FOR COCKPIT DISPLAYS
RICHARD HOCKENBROCK (Tektronix, Inc., Beaverton, OR) Optical Engineering (ISSN 0091-3286), vol. 29, Aug. 1990, p. 843-848. refs
Copyright

An integrated taut shadow mask color CRT in sizes 5x5 and 6x6 inches has been developed for heads down displays in jet fighter and helicopter applications. Completely viewable in a full sunlight ambient environment, these CRTs can display high

resolution maps and tactical information while withstanding the rugged vibration environment of a military aircraft. Author

A90-45354
CLUTTER REJECTION AND TRANSMITTER-RECEIVER REQUIREMENTS IN AN AIRBORNE RADAR
PHILIPPE LACOMME (Thomson-CSF, Airborne Radars Dept., Montrouge, France) (1989 International Symposium on Noise and Clutter Rejection in Radars and Imaging Sensors, Kyoto, Japan, Nov. 14-16, 1989) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 5, June 1990, p. 11-13.
Copyright

Ground clutter rejection requirements imposed on the exciter transmitter-receiver units of multirole airborne radar are examined. Methods are given to determine the characteristics of the units, such as noise, spurious spectral lines level, and analog-to-digital converter (ADC) dynamics, in both high- and medium-pulse-repetition-frequency modes of operation. It is shown that the spectral noise does not depend on either the wave form or the Doppler bandwidth. The reference oscillator spectral noise must be about -155 dBc/Hz. The level of spurious lines generally depends only on the duty cycle, and the requirement is -80 dBc for each line. ADC requires 12 to 14 b. The high-frequency mode is the most promising for detecting targets with very low radar cross sections in head-on configuration (free clutter domain).
I.E.

A90-45446* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TASK-ORIENTED DISPLAY DESIGN - CONCEPT AND EXAMPLE
TERENCE S. ABBOTT (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 15 p. Previously announced in STAR as N90-15101. refs
(SAE PAPER 892230) Copyright

The general topic was in the area of display design alternatives for improved man-machine performance. The intent was to define and assess a display design concept oriented toward providing this task-oriented information. The major focus of this concept deals with the processing of data into parameters that are more relevant to the task of the human operator. Closely coupled to this concept of relevant information is the form or manner in which this information is actually presented. Conventional forms of presentation are normally a direct representation of the underlying data. By providing information in a form that is more easily assimilated and understood, a reduction in human error and cognitive workload may be obtained. A description of this proposed concept with a design example is provided. The application for the example was an engine display for a generic, twin-engine civil transport aircraft. The product of this concept was evaluated against a functionally similar, traditional display. The results of this evaluation showed that a task-oriented approach to design is a viable concept with regard to reducing user error and cognitive workload. The goal of this design process, providing task-oriented information to the user, both in content and form, appears to be a feasible mechanism for increasing the overall performance of a man-machine system. Author

A90-45484
SOFTWARE MAINTENANCE ON THE AIRBUS FAMILY
J. GROSSIN and R. COUSTALAT (Aerospatiale, Toulouse, France) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 8 p. Previously announced in STAR as N90-23931.
(SAE PAPER 892326) Copyright

Two technologies used to ease software changes on board the Airbus family are described. On one all computers with a database have teleloading capability from an MDDU (Multipurpose Disk Drive Unit): configuration management is performed through MCDU (Multipurpose Control and Display Unit), teleloading is monitored by the onboard computers. On the other an extensive use of OBRM (On Board Replaceable Module) is made to implement operational program of all computers on which changes are expected. Installation of the modules in the computer builds the part number, solving automatically the configuration control problem; special techniques are used to check compatibility between OBRM's of a given set and between this set and the computer hardware. Author

A90-45485
USE OF ONBOARD DATA LOADERS
DEBORAH MILLER (Honeywell, Inc., Sperry Commercial Flight Systems Group, Phoenix, AZ) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 7 p.
(SAE PAPER 892327) Copyright

Onboard Data Loaders are designed to load operational flight programs into an airborne computer without removing the computer from the aircraft. The load operation or transfer of data from the media to the computer is defined by Aeronautical Radio, Inc. (ARINC) Report 615 (1), and is common for all users. The procedural use of the onboard software loader is standardized by the particular airframe manufacturer. This paper addresses the development of design standards (minimum requirements) for the systems that interface with the Onboard Data Loader. In addition, the paper describes a generalized Onboard Data Loading Procedure. Author

A90-45508
AN INTERFACING SOLUTION FOR REAL-TIME AVIONICS DEVELOPMENT
R. B. HUMPHREY and F. H. WILLIAMS (Douglas Aircraft Co., Long Beach, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 11 p.
(SAE PAPER 892357) Copyright

Douglas Aircraft Company (DAC) of Long Beach, California, uses a real-time development environment, the avionics evaluation facility (AEF), to develop new avionics systems for the MD-11 aircraft. The development environment includes a host computer, input/output (I/O) software/hardware interface, and avionics system. The I/O interface developed at DAC, the interface microcomputer system (IMS), is a highly developed, flexible, practical, reliable, and sophisticated system for interfacing the host computer to the avionics system. This paper describes the IMS from its historical background to its present configuration in the AEF environment. Author

A90-45509
INTEGRATED DIAGNOSTICS (ID) FOR ADVANCED AVIONICS ARCHITECTURES
ALAN L. BRIDGES (Lockheed Electronics Co., Inc., Plainfield, NJ) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 16 p. refs
(SAE PAPER 892359) Copyright

The three armed services have prepared a Joint Integrated Avionics Plan, which proposes to utilize as much common architecture as feasible. Inherent in this project is the requirement to address Integrated Diagnostics (ID). The National Security Industrial Association Integrated Diagnostics Working Group has been reviewing these documents and working closely with the Joint Services Group to provide consensus for integration of all factors affecting fielding of ID for advanced avionics architectures (AAAs). AAAs and expert system concepts capable of diagnosing system faults call for total integration of the embedded and support diagnostics. The main challenge of integrated avionics (IA) systems designers is to anticipate and understand the ID product requirements, factor these into the designs, and monitor compliance with the requirements as the product moves through various stages of development, production, and operational use. This paper reviews AAAs, issues associated with testability/ID, preventive maintenance (PM) integration with ID, and emerging technologies required for an effective demonstration of ID for AAAs. Author

N90-25138# National Aeronautical Establishment, Ottawa (Ontario). Flight Research Lab.
AN ACCURATE NUMERICAL TECHNIQUE FOR DETERMINING FLIGHT TEST RATE GYROSCOPE BIASES PRIOR TO TAKEOFF
G. M. BEAUCHAMP Mar. 1989 5 p
(AD-A220987; NAE-AN-59; NRC-30116) Avail: NTIS HC A01/MF A01 CSCL 01/4

Rate gyroscope biases play an important role in flight tests requiring flight path reconstruction, a method often used in aircraft parameter estimation. The biases can drift with time, be affected by system power up and, ideally, should be calibrated before each flight to maintain optimum performance. A numerical method is detailed to determine the biases of high quality flight test rate gyroscopes immediately prior to a flight. The accuracy of the method is such that the earth rate is clearly sensed and accounted for, a variable rarely considered in flight testing. The method requires minimal time and no calibration hardware. Author

N90-25981*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
QUALITATIVE EVALUATION OF A CONFORMAL VELOCITY VECTOR DISPLAY FOR USE AT HIGH ANGLES-OF-ATTACK IN FIGHTER AIRCRAFT
DENISE R. JONES and JAMES R. BURLEY, II Jun. 1990 11 p
(NASA-TM-102629; NAS 1.15:102629) Avail: NTIS HC A03/MF A01 CSCL 01/4

A piloted simulation study was conducted to evaluate the utility of a display device designed to illustrate graphically and conformally the approximate location of a fighter aircraft's velocity vector. The display device consisted of two vertical rows of light emitting diodes (LED's) located toward the center of the cockpit instrument panel to each side of the control stick. The light strings provided a logical extension of the head up display (HUD) velocity vector symbol at flight path angles which exceeded the HUD field-of-view. Four test subjects flew a modified F/A-18 model with this display in an air-to-air engagement task against an equally capable opponent. Their responses to a questionnaire indicated that the conformal velocity vector information could not be used during the scenarios investigated due to the inability to visually track a target and view the lights simultaneously. Author

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A90-42653#
DESIGN OF AEROENGINES IN A LOW-FUEL PRICE SCENARIO
S. J. HARTROPP (Rolls Royce, PLC, Derby, England) and K. W. BUSHELL (Rolls Royce, Inc., Atlanta, GA) IN: Annual General Meeting of the Canadian Aeronautics and Space Institute, 36th, Ottawa, Canada, May 15, 16, 1989, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1989, p. 1-1 to 1-15.

The driving parameters for aircraft engine design have been reassessed to account for the stabilization of fuel price in the vicinity of 50 cents per gallon. A program embracing studies in the fields of operating cost analysis, reliability research and engine-specific thrust effects established principles reflecting the relative importance of engine direct operating cost. The same factors (which are fuel consumption, weight, first cost, and maintenance cost) influence the aircraft life-cycle cost and market considerations such as legislative compliance, operator acceptance, and passenger appeal. The effect of applying these principles to a new powerplant and the ongoing development of current powerplants is being evaluated. Author

A90-42657#
AN EXPERIMENTAL INVESTIGATION OF THE VELOCITY FIELD IN A REVERSE-FLOW COMBUSTOR
J. T. C. HU, R. A. CUSWORTH, and J. P. SISLIAN (Toronto, University, Downsview, Canada) IN: Annual General Meeting of the Canadian Aeronautics and Space Institute, 36th, Ottawa, Canada, May 15, 16, 1989, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1989, p. 10-1 to 10-12. refs (Contract NSERC-G-2016)

An experimental flow visualization study including LDV flowfield measurements was conducted for a toroidal, vortex reverse-flow annular sector combustor. Test conditions were both cold-flow, with and without fuel injection, and hot flow; the measurements obtained for the two components of the mean velocity and the three components of the turbulent stresses were used to ascertain the effects of heat addition by combustion on the turbulence and flow properties in the sector combustor. The comparison of hot and cold flow measurements indicates that heat addition by combustion intensifies all vortex and recirculation regions due to decreased density. In addition, the fuel jet near the injector inlet is laminarized by the greater kinematic viscosity of the fuel-air mixture. O.C.

A90-42662#
LIFE ESTIMATION OF A GAS TURBINE AFTERBURNER SPRAYBAR
N. C. BELLINGER, P. C. PATNAIK, and R. THAMBURAJ (Hawker Siddeley Canada, Inc., Orenda Div., Mississauga, Canada) IN: Annual General Meeting of the Canadian Aeronautics and Space Institute, 36th, Ottawa, Canada, May 15, 16, 1989, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1989, p. 17-1 to 17-19. Research supported by DND. refs

An investigation has been conducted to ascertain the durability and damage tolerance of gas turbine afterburner spray bars, which are susceptible to thermally-induced fatigue cracking. Two of the 16 spray bars in an afterburner were instrumented with five thermocouples apiece, in order to monitor temperature variations at various critical locations of the spray bars during afterburner operations; thermal stresses were calculated on the basis of temperature gradients obtained by these tests. A deterministic fracture-mechanics approach was then used to estimate the life to dysfunction for each of the critical areas. Cracks that go undetected during inspection are identified as probable causes of subsequent failures. O.C.

A90-42670#
FILM COOLING OF TURBINE BLADES - TWO DIMENSIONAL EXPERIMENTS AND NUMERICAL SIMULATIONS
D. SINITSIN, N. DJILALI, I. GARTSHORE, and M. SALCUDEAN (British Columbia, University, Vancouver, Canada) IN: Annual General Meeting of the Canadian Aeronautics and Space Institute, 36th, Ottawa, Canada, May 15, 16, 1989, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1989, p. 35-1 to 35-14. Research supported by NSERC and Pratt and Whitney Canada. refs

To better understand the complicated fluid flow and heat transfer that occur in the film cooling of turbine blades, two-dimensional experiments and numerical simulations have been done for the flow from a flush inclined slot entering a uniform flow in zero-pressure gradient. Slot angles of 20 and 40 deg have been studied, and 'mass flow ratios' of about 1 or less have been considered. The numerical simulations used finite difference methods with the k-epsilon model of turbulence. Author

A90-42688*# Sverdrup Technology, Inc., Brook Park, OH.
ANALYSIS OF INTERNAL FLOW IN A VENTRAL NOZZLE FOR STOVL AIRCRAFT
C. FREDERIC SMITH (Sverdrup Technology, Inc., Brook Park, OH) and JACK G. MCARDLE (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion

Conference, 26th, Orlando, FL, July 16-18, 1990. 20 p. Previously announced in STAR as N90-23404. refs
(Contract NAS3-25266)
(AIAA PAPER 90-1899) Copyright

Short takeoff and vertical landing (STOVL) aircraft are planned for possible future development. For these aircraft, the same propulsion system will provide power for lift, hover, and horizontal flight. To accomplish this, many designs include a ventral nozzle to provide part of the vertical thrust required. Understanding and predicting the internal aerodynamic flow caused by a single exhaust duct opening are highly desirable in assessing this concept. A numerical simulation of a ventral nozzle is presented and the results are compared with experimental data. Comparisons include visualizations of the flow along the ventral duct walls and in the tailpipe plane of symmetry. Performance calculations are also compared with measured values. Author

A90-42690*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
COMPUTATIONAL ANALYSIS OF THE FLOWFIELD OF A TWO-DIMENSIONAL EJECTOR NOZZLE
Y. H. CHOI and W. Y. SOH (NASA, Lewis Research Center, Cleveland, OH; Sverdrup Technology, Inc., Brook Park, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 16 p. Previously announced in STAR as N90-23406. refs
(Contract NAS3-25266)
(AIAA PAPER 90-1901) Copyright

A time-iterative full Navier-Stokes code, PARC, is used to analyze the flowfield of a two-dimensional ejector nozzle system. A parametric study was performed for two controlling parameters, duct to nozzle area ratio and nozzle pressure ratio. Results show that there is an optimum area ratio for the efficient pumping of secondary flow. At high area ratios, a freestream flow passes directly through the mixing duct without giving adequate pumping. At low area ratios, the jet boundary blocks the incoming flow. The nozzle pressure ratio variation shows that the pumping rate increases as the pressure ratio increases, provided there is no interaction between the shroud wall and the shock cell structure. Author

A90-42691*# General Motors Corp., Indianapolis, IN.
EXPERIMENTAL EVALUATION OF EXPENDABLE SUPERSONIC NOZZLE CONCEPTS
V. BAKER, O. KWON, B. VITTAL (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN), B. BERRIER, and R. RE (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 10 p. refs
(AIAA PAPER 90-1904) Copyright

Exhaust nozzles for expendable supersonic turbojet engine missile propulsion systems are required to be simple, short and compact, in addition to having good broad-range thrust-minus-drag performance. A series of convergent-divergent nozzle scale model configurations were designed and wind tunnel tested for a wide range of free stream Mach numbers and nozzle pressure ratios. The models included fixed geometry and simple variable exit area concepts. The experimental and analytical results show that the fixed geometry configurations tested have inferior off-design thrust-minus-drag performance in the transonic Mach range. A simple variable exit area configuration called the Axi-Quad nozzle, combining features of both axisymmetric and two-dimensional convergent-divergent nozzles, performed well over a broad range of operating conditions. Analytical predictions of the flow pattern as well as overall performance of the nozzles, using a fully viscous, compressible CFD code, compared very well with the test data. Author

A90-42692*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXTERNAL NOZZLE FLAP DYNAMIC LOAD MEASUREMENTS ON F-15 S/MTD MODEL
JOHN M. SEINER, MICHAEL K. PONTON, ODIS C. PENDERGRAFT, JR., JAMES C. MANNING, and MARY L. MASON (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 16 p. refs
(AIAA PAPER 90-1910)

Dynamic pressure loads were obtained on 1/12 scale models of the F-15B production aircraft and the F-15 S/MTD experimental aircraft with rectangular nozzles and canards. Flight Mach numbers from 0.51 to 1.20 were studied for aircraft angles of attack from 0 to 10 deg and nozzle pressure ratios from 1.00 to 5.09. The results show that dynamic levels are lower in the internozzle region of twin rectangular nozzles than are levels found with twin axisymmetric nozzles. At other locations, the levels associated with both geometries are of the same order of magnitude when normalized by aircraft dynamic Q. At Mach number of 0.51, the loads spectrum is dominated by plume shock noise processes for both geometries. Above Mach 0.51, this mechanism is associated with either vortex bursting from a forward location or turbulent boundary layer separation over the nozzle external flaps. At supersonic speeds both geometries show significantly decreased load levels. C.D.

A90-42693#
STALL CELL BLOCKAGE IN A HIGH-SPEED MULTISTAGE AXIAL-FLOW COMPRESSOR
STEVEN E. GORRELL, WILLIAM W. COPENHAVER (USAF, Aero Propulsion and Power Laboratory, Wright-Patterson AFB, OH), and WALTER F. O'BRIEN (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 11 p. Research supported by USAF. refs
(AIAA PAPER 90-1913)

Current in flight demands on aircraft gas turbine engines have elevated rotating stall performance and recoverability to a key parameter in the design of axial-flow compressors. In-stall test results from a 10-stage, high-speed, axial-flow compressor are presented. The test results detail exit Mach number time histories during in-stall operation. These time histories are compared to changes in 10th-stage in-stall pressure characteristics when geometry is varied in the first three stages. Test cases presented include throttle and variable geometry changes for compressor operation at 75 percent of design corrected speed. The results suggest that stall cell zones based on axial Mach number vary as throttle and variable geometry changes are made. In general, reverse flow and leading edge transition zones change little until near recovery or at high throttle closure levels. While the compressor was operating in rotating stall on the hysteresis portion of the quasi-steady pressure characteristic, the majority of the Mach number distribution changes occur between the unstalled and trailing edge transition zone. The analysis presented indicates that in-stall stage characteristics depend not only on stage geometry but also on stall cell blockage levels. Author

A90-42694#
APPLICATION OF 3-D VISCOUS CODE IN THE DESIGN OF A HIGH PERFORMANCE COMPRESSOR
E. WORTH and N. PLEHN (Williams International, Walled Lake, MI) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 13 p. refs
(AIAA PAPER 90-1914) Copyright

To incorporate the three-dimensional viscous code into the compressor design system, a data base characterizing the flow details of several high performance rotors was generated. The solutions were studied in detail to identify loss mechanisms and the mass-average of the flow properties were compared to the axisymetric design solution. Using the information from this data base, a high pressure rotor, which was a significant extension of current design practice was designed using the three-dimensional viscous analysis to guide the design iterations. The final rotor configuration was altered significantly from the preliminary design configuration due to the three-dimensional viscous results. Author

A90-42695#
APPLICATION OF SWEEP TO IMPROVE THE EFFICIENCY OF A TRANSONIC FAN. I - DESIGN
R. J. NEUBERT, D. E. HOBBS, and H. D. WEINGOLD (Pratt and Whitney Group, East Hartford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 14 p. refs
(Contract N00140-82-CH-532)
(AIAA PAPER 90-1915) Copyright

The concept of aerodynamic sweep has been applied to the design of a highly swept, low aspect ratio fan rotor. This baseline fan, designed and tested in 1986-1987, achieved its design goals. The design of the swept rotor with the same application requirements was also completed in 1986. The swept design was predicted to be shock free and to improve fan rotor adiabatic efficiency by 1.5 percent. Author

A90-42696#
SMALL-SCALE INLET TESTING FOR LOW COST SCREENING APPLICATIONS
WILLIAM P. NORBY (McDonnell Aircraft Co., Saint Louis, MO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 11 p. refs
(AIAA PAPER 90-1926) Copyright

A validation program has been completed showing that 5 percent scale isolated inlet models can be successfully tested in a 1 x 1 foot wind tunnel. The validation was conducted in the 0.6 to 2.0 Mach number range. This small scale test capability was developed to reduce the cost of experimental screening for advanced inlet concepts. The validation was accomplished by replicating, at a smaller scale, a previously tested two-dimensional inlet concept for test in McDonnell Aircraft Company's Trisonic Wind Tunnel (TWT). Inlet data previously obtained in the NASA Lewis 8 x 6 foot wind tunnel using a 12-percent model served as the baseline. The new 5-percent model was tested in the TWT at identical Mach numbers and Reynolds numbers as the 12-percent model. Data analyses were conducted to determine accuracy of the small scale test technique. Good agreement was indicated in major inlet performance parameters for both subsonic and supersonic test conditions. Testing was also conducted throughout the Reynolds numbers ranges of the tunnel to determine the magnitude and importance of Reynolds number effects within the TWT's capabilities. No variation in inlet recovery was detected between engine face diameter based Reynolds numbers of 1.0 million to 2.6 million at any Mach number, but Reynolds numbers less than 1.0 million resulted in recovery losses of up to 2 percent at Mach 0.6. Author

A90-42706#
SUPPRESSION OF 'BUZZ' INSTABILITY BY GEOMETRICAL DESIGN OF THE FLAMEHOLDER
E. GUTMARK, K. C. SCHADOW (U.S. Navy, Naval Weapons Center, China Lake, CA), M. N. R. NINA, and G. P. A. PITA (Instituto Superior Tecnico, Lisbon, Portugal) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 14 p. refs
(AIAA PAPER 90-1966)

Passive control methods are extended to bluff body flameholder configurations. The concepts of multistepped geometry and axial vorticity generators were implemented in the flameholders design. Flammability limits were measured for the different geometries and compared for the standard disk stabilizer. The wall static pressure rms was used to characterize the domain of rough combustion as a function of the mixture velocity and equivalence ratio for the different bluff body geometries and for two hot pipe lengths. Differences in the pressure fluctuations amplitude and in the stability combustion domain of the different flameholders tested were observed. The multistepped and the axial vorticity generating flameholders reduced significantly the region of rough combustion without affecting the flammability limits. Author

A90-42712#
OPERATION OF THE RAM ACCELERATOR IN THE TRANSDETONATIVE VELOCITY REGIME
E. A. BURNHAM, A. E. KULL, C. KNOWLEN, A. P. BRUCKNER, and A. HERTZBERG (Washington, University, Seattle) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 9 p. Research supported by Olin Corp. refs
(Contract F08635-89-C-0196)
(AIAA PAPER 90-1985) Copyright

The results of recent experiments with a ram accelerator in the transdetonative velocity regime are presented in this paper. The ram accelerator is a ramjet-in-tube projectile accelerator. The tube acts as the outer cowling of the ramjet, and the combustion process travels with the projectile, generating a pressure distribution which produces forward thrust on the projectile. Several different modes of combustion are possible. Subsonic, thermally choked combustion theoretically allows a projectile to be accelerated to the Chapman-Jouguet (C-J) detonation velocity of a particular gas mixture. In the superdetonative velocity regime the projectile is accelerated while always traveling faster than the C-J velocity, and in the transdetonative regime (85-115 percent of C-J detonation velocity) the projectile transitions smoothly from a subsonic to a superdetonative combustion mode. Experimental confirmation of transdetonative ram accelerator operation is presented in which 70-g projectiles are accelerated through a 16 m long, 38 mm bore accelerator tube to velocities above 2400 m/s. Author

A90-42718#
PERFORMANCE IMPROVEMENT OF AN ERODED AXIAL FLOW COMPRESSOR USING WATER INJECTION
W. TABAKOFF (Cincinnati, University, OH), S. KAUSHIK, and A. N. LAKSHMINARASIMHA AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 11 p. Research supported by DOE. refs
(AIAA PAPER 90-2016) Copyright

The vulnerability of high-performance aircraft, ship, and power plant gas turbines to particle-laden flows is of serious concern to both manufacturers and users of these turbomachines. The presence of solid particles through the engines is associated with a reduction in power output, costly fuel expenses, frequent overhaul periods, and in some instances the safety of the operation itself. The deteriorating effects from erosion in axial flow compressors manifests itself by decreasing the following: surge margin, air mass flow rate, the pressure rise across the compressor, the thrust and increasing the S.F.C. of the engine. The crippling effect on the overall performance of a gas turbine engine due to erosion can be overcome temporarily by injecting water at the face of the axial flow compressor of the engine. This paper will present first the compressor performance degradation when exposed to particulate laden flow and then a qualitative analysis of how the lost performance can be restored by water injection in the compressor. An analysis of the thermodynamic effects of water injection upon axial compressor performance using stage-stacking method and a thermodynamic model is presented. Author

A90-42719#
NOZZLE DESIGN OPTIMIZATION BY METHOD-OF-CHARACTERISTICS
M. GOEING (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, Federal Republic of Germany) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 12 p. refs
(AIAA PAPER 90-2024) Copyright

The first step in thrust nozzle design for hypersonic aircraft is the determination of isentropic wall contours. This paper discusses a method based on the theory of characteristis for the design of ideal, two-dimensional, supersonic nozzle configurations with different geometric attributes. Corresponding to the design criteria, such as minimum length and optimum thrust efficiency, relations between desired properties of the flow field and nozzle geometry parameters are found, and a family of length-optimized nozzles is defined. Isentropic wall contours obtained for design point

conditions form the basis for the further design work. In order to meet the integration and performance requirements for the thrust nozzle, the ideal wall contours must be cut back, and an optimum contour adjustment for the variation of throat area and flap angles must be achieved. For the single expansion ramp nozzle, the effects of nozzle geometry parameters on the performance over the flight range are investigated. Author

A90-42720#
AIRCRAFT PROPULSION CONTROL SYSTEMS FOR THE NEXT CENTURY
CHARLES A. SKIRA (USAF, Aero Propulsion and Power Laboratory, Wright-Patterson AFB, OH) and MARK AGNELLO (U.S. Navy, Naval Air Propulsion Center, Trenton, NJ) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 14 p. refs
(AIAA PAPER 90-2034)

The paper describes a conceptual control system design based on advanced technologies currently in the exploratory development phase, and, in some cases, emerging into the advanced development phase. It explores future propulsion control systems that focus on improvements in three areas: (1) significantly reducing control system weight; (2) enhancing engine performance (thrust, sfc, etc.); and (3) improving control system reliability and tolerance to high threat environments (temperature, vibration, EMI, EMP, etc.). The factors that will influence the design and hardware configuration of future propulsion control systems are described. Design goals for future systems, based on the DOD/NASA IHPTET Initiative, and projections of emerging technology capability (and availability) form the basis for future propulsion control system design requirements and for estimating future hardware configurations. Author

A90-42728*# Analytical Services and Materials, Inc., Hampton, VA.
A COMPUTATIONAL INVESTIGATION OF FLOW LOSSES IN A SUPERSONIC COMBUSTOR
DAVID W. RIGGINS (Analytical Services and Materials, Inc., Hampton, VA) and CHARLES R. MCCLINTON (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 21 p. refs
(AIAA PAPER 90-2093) Copyright

This computational investigation provides a detailed comparative study of both non-reacting and reacting supersonic combustor flow-fields and attendant flow losses. Three different injection configurations in the same combustor are examined; a swept-sided ramp with base hydrogen injection, a straight ramp with base hydrogen injection and a thirty-degree downstream directed wall jet. Detailed comparisons are made with available reacting experimental data for the swept and the unswept ramps. A seven reaction, seven species reaction model as well as a global (one reaction) model are used for all three reacting cases. Relative performance (as measured by thrust) of all cases are described. Details of the flow, mixing, and combustion processes are discussed. Author

A90-42729*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLOW ESTABLISHMENT IN A GENERIC SCRAMJET COMBUSTOR
P. A. JACOBS (NASA, Langley Research Center; Institute for Computer Applications in Science and Engineering, Hampton, VA), R. C. ROGERS, E. H. WEIDNER (NASA, Langley Research Center, Hampton, VA), and R. D. BITTNER (Analytical Services and Materials, Inc., Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 15 p. refs
(AIAA PAPER 90-2096) Copyright

The establishment of a quasi-steady flow in a generic scramjet combustor is studied for the case of a time varying inflow to the combustor. Such transient flow is characteristic of the reflected-shock tunnel and expansion-tube test facilities. Several numerical simulations of hypervelocity flow through a straight-duct combustor with either a side-wall-step fuel injector or a centrally-located strut injector are presented. Comparisons are made between impulsively started but otherwise constant flow conditions (typical of the expansion-tube or tailored operation of the reflected-shock tunnel) and the relaxing flow produced by the 'undertailored' operation of the reflected-shock tunnel. Generally the inviscid flow features, such as the shock pattern and pressure distribution, were unaffected by the time varying inlet conditions and approached steady state in approximately the times indicated by experimental correlations. However, viscous features, such as heat transfer and skin friction, were altered by the relaxing inlet flow conditions. Author

A90-42741*# Allied-Signal Aerospace Co., Phoenix, AZ.
PARAMETRIC EVALUATION OF THE AERODYNAMIC PERFORMANCE OF AN ANNULAR COMBUSTOR-DIFFUSER SYSTEM
R. SRINIVASAN, W. G. FREEMAN, J. W. GRAHMANN, and E. B. COLEMAN (Allied-Signal Aerospace Co., Garrett Engine Div., Phoenix, AZ) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 7 p. Research supported by NASA. refs
(Contract F33615-84-C-2427)
(AIAA PAPER 90-2163) Copyright

This study experimentally determined the effects of dominant geometric and flow parameters on the aerodynamic performance of an annular combustor-diffuser system. For each parametric configuration, data were obtained at 13 different flow rates through the inner annulus, outer annulus, and combustor dome. The parametric effects investigated included the dump gap dimension, flow splits, prediffuser inlet velocity profile, and combustor channel height. During these measurements, the average prediffuser inlet Mach number was 0.305. The measured static pressure recovery coefficient and the total pressure loss coefficient in the prediffuser as well as the overall system are presented in this paper. The study found that the performance of the combustor-diffuser system improves with increasing dome flow rate or dump gap dimension. Author

A90-42752#
MEASURED OPERATING CHARACTERISTICS OF A RECTANGULAR COMBUSTOR/INLET ISOLATOR
DAVID A. BEMENT, JAMES R. STEVENS, and M. W. THOMPSON (Johns Hopkins University, Laurel, MD) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 9 p. refs
(AIAA PAPER 90-2221) Copyright

Data characterizing the performance of a rectangular constant area combustor/inlet isolator duct were obtained in semi-freejet tests of a scramjet engine model. Isolators ducts have been previously demonstrated to be an effective mechanism for stabilizing combustion induced disturbances and preventing combustor/inlet interactions. The current database for shock structures in rectangular ducts, however, is insufficient for designing isolators for high speed (Mach 4-10) propulsion systems. This report is intended to contribute to that database and discuss the shortcomings of acquiring isolator data in a multi-component engine test. A comparison is made with an empirical correlation that characterizes shocks in cylindrical ducts to determine its applicability to this rectangular isolator. Measurements used to make this comparison include boundary layer and core flow pitot pressures, total temperature, wall heat transfer, air flow rate, and axial pressure distributions. Author

A90-42765#
HOT GAS ENVIRONMENT AROUND STOVL AIRCRAFT IN GROUND PROXIMITY. I - EXPERIMENTAL STUDY
J. SULLIVAN, S. N. B. MURTHY (Purdue University, West Lafayette, IN), and R. MACLEAN AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 12 p. refs
(AIAA PAPER 90-2269) Copyright

In connection with the problems of the ingestion of exhaust gases of engines in V/STOL and STOVL aircraft in ground effect, an experimental investigation was conducted on a typical model configuration using marker nephelometry to establish the interactions between the jets, forward velocity, and the ground. The test rig consisted of a two-inlet configuration with four low subsonic velocity jets impacting vertically on a flat plate, the vertical distance between the plate and model under-surface being adjustable. A wind tunnel provided forward air flow to simulate landing into a wind with a velocity which could be set at 0 to 0.1 times the jet velocity. A video movie of concentration distribution revealed several vortical features in the interaction region, which were affected variously by the distance between the ground plane and model, and the inlet suction. The frame-averaged data compared favorably with time-averaged predictions carried out elsewhere in a companion investigation. However, such predictions did not seem to reveal several aspects of the vortical flow features which should affect instantaneous distortion into the engine inlet. Author

A90-42766*# Illinois Univ., Urbana.
HOT GAS ENVIRONMENT AROUND STOVL AIRCRAFT IN GROUND PROXIMITY. II - NUMERICAL STUDY
D. K. TAFTI and S. P. VANKA (Illinois, University, Urbana) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 21 p. refs
(Contract NAG3-1026)
(AIAA PAPER 90-2270) Copyright

Ingestion of hot exhaust gases by the engines of STOVL aircraft has been an important research problem for several years. The hot gas environment around STOVL aircraft is three-dimensional and turbulent. In this study, the Navier-Stokes equations governing the hot gas ingestion flowfield are solved by an efficient finite-difference calculation procedure. The complete geometry including the head wind and the fuselage is simulated. Four demonstration calculations with variations in the height of the fuselage and the head wind velocity are presented. It is shown that the calculation procedure efficiently provides a solution to the governing equations and produces realistic descriptions of the flow and temperature fields. Author

A90-42767*# Pratt and Whitney Aircraft, West Palm Beach, FL.
EVOLUTION OF ENGINE CYCLES FOR STOVL PROPULSION CONCEPTS
R. L. BUCKNELL, R. H. FRAZIER (United Technologies Corp., Pratt and Whitney Group, West Palm Beach, FL), and D. J. GIULIANETTI (NASA, Ames Research Center, Moffett Field, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 7 p.
(AIAA PAPER 90-2272) Copyright

Short Take-off, Vertical Landing (STOVL) demonstrator concepts using a common ATF engine core are discussed. These concepts include a separate fan and core flow engine cycle, mixed flow STOVL cycles, separate flow cycles convertible to mixed flow, and reaction control system engine air bleed. STOVL propulsion controls are discussed. C.D.

A90-42777*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
METHODS FOR DETERMINING THE INTERNAL THRUST OF SCRAMJET ENGINE MODULES FROM EXPERIMENTAL DATA
RANDALL T. VOLAND (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 15 p. refs
(AIAA PAPER 90-2340) Copyright

Methods for calculating zero-fuel internal drag of scramjet engine modules from experimental measurements are presented. These methods include two control-volume approaches, and a pressure and skin-friction integration. The three calculation techniques are applied to experimental data taken during tests of a version of the NASA parametric scramjet. The methods agree to within seven percent of the mean value of zero-fuel internal drag even though several simplifying assumptions are made in the analysis. The mean zero-fuel internal drag coefficient for this particular engine is calculated to be 0.150. The zero-fuel internal drag coefficient when combined with the change in engine axial force with and without fuel defines the internal thrust of an engine. V.T.

A90-42793#
STRUCTURAL AND AERODYNAMIC ANALYSIS OF A LARGE SCALE ADVANCED PROPELLER BLADE
O. YAMOMOTO and R. AUGUST (Sverdrup Technology, Inc., Brook Park, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 12 p. refs
(AIAA PAPER 90-2401)

A finite element structure code and a finite difference Euler solver are combined to provide a more accurate analysis of a large scale propfan. The NASTRAN finite element code is used to compute the blade deflection due to centrifugal and aerodynamic loads, and the NASPROP finite difference three-dimensional Euler code is employed to compute the steady state aerodynamic load of the deflected blade. The effects of deflection on the aerodynamic and propeller performance characteristics are discussed. The local pressure profiles of deflected and undeflected blade models are compared with test data. The results show that improvements can be made by including proper blade deflection in the numerical model. Author

A90-42806#
ACTIVE COMBUSTION CONTROL IN A COAXIAL DUMP COMBUSTOR
K. C. SCHADOW, E. GUTMARK, and K. J. WILSON (U.S. Navy, Naval Weapons Center, China Lake, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 14 p. refs
(AIAA PAPER 90-2447)

Suppression of combustion instability in a dump combustor was demonstrated with open loop and closed-loop active control systems. The open loop active control system applied high frequency acoustic forcing to break down the coherence of the large-scale vortical structures, thus reducing the periodic heat release which excites the instability. The closed-loop controller used the CH-emission signal or the pressure fluctuations, after filtration, to lock the acoustic excitation at various relative phase angles. The pressure locking was more effective in suppressing the oscillations at a relative phase angle range of 250 to 330 deg. The reduced oscillations were observed by both CH and pressure sensors. The CH locking was significantly less effective relative to the pressure locking, but had a similar range of phase angles in which combustion oscillations were suppressed. Author

A90-42808*# SOL-3 Resources, Inc., Reading, MA.
INTRODUCING THE VRT GAS TURBINE COMBUSTOR
JERRY O. MELCONIAN (SOL-3 Resources, Inc., Reading, MA), ABDU A. MOSTAFA (Textron Lycoming, Stratford, CT), and HUNG LEE NGUYEN (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 13 p. Previously announced in STAR as N90-23591. refs
(AIAA PAPER 90-2452) Copyright

An innovative annular combustor configuration is being developed for aircraft and other gas turbine engines. This design has the potential of permitting higher turbine inlet temperatures by reducing the pattern factor and providing a major reduction in NO(x) emission. The design concept is based on a Variable Residence Time (VRT) technique which allows large fuel particles adequate time to completely burn in the circumferentially mixed primary zone. High durability of the combustor is achieved by dual function use of the incoming air. The feasibility of the concept was demonstrated by water analogue tests and 3-D computer modeling. The computer model predicted a 50 percent reduction in pattern factor when compared to a state of the art conventional combustor. The VRT combustor uses only half the number of fuel nozzles of the conventional configuration. The results of the

chemical kinetics model require further investigation, as the NO(x) predictions did not correlate with the available experimental and analytical data base. Author

A90-42813#
OPTIMIZATION STUDIES FOR THE PW305 TURBOFAN
D. J. KARANJIA and R. A. HARVEY (Pratt and Whitney Canada, Longueuil) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 6 p.
(AIAA PAPER 90-2520) Copyright

This paper discusses the studies that were done in the Advanced Design department of Pratt & Whitney Canada to optimize the design of the PW305 turbofan engine for the business aircraft market. It first shows how mechanical and aerodynamic considerations can constrain the choice of cycle pressure ratio and turbine inlet temperature, and then shows how the choice of fan diameter and bypass pressure ratio is best chosen by considering the engine/airframe combination and 'flying' it over a representative mission. Author

A90-42814#
THE LF500 AND THE REGIONAL AIRLINE MARKET
K. R. DULY (Textron Lycoming, Stratford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 5 p.
(AIAA PAPER 90-2521) Copyright

The discussion deals with the 'lessons learned' in operating the ALF502 turbofan engine in the Regional Airline Marketplace. Particularly, the maintainability, reliability, cost of ownership and durability issues are addressed and how these 'lessons learned' have been applied to the current product. In addition, the growth of the LF500 to higher thrust classes wil be addressed and how this will be achieved in light of experience gained in the operating environment. Author

A90-42815#
THE GMA 2100 AND GMA 3007 ENGINES FOR REGIONAL AIRCRAFT
R. E. RIFFEL, T. F. PIERCY, T. F. MCKAIN, and E. T. LEWIS (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 8 p.
(AIAA PAPER 90-2523) Copyright

The programs of the GMA 2100 turboprop and GMA 3007 turbofan engines are presented along with a description of the technical features and status of the T406 engine. This includes details of design, performance ratings, and current and future applications. These engines are developed to power the new generation of regional aircraft that require low operating economics, operational flexibility, and passenger comfort. Many advanced technologies are incorporated into these engines, along with the important features of designed-in reliability and maintainability. R.E.P.

A90-43218* Jordan Univ. of Science and Technology, Irbid.
SHAFT FLEXIBILITY EFFECTS ON THE FORCED RESPONSE OF A BLADED-DISK ASSEMBLY
N. KHADER (Jordan University of Science and Technology, Irbid) and R. G. LOEWY (Rensselaer Polytechnic Institute, Troy, NY) Journal of Sound and Vibration (ISSN 0022-460X), vol. 139, June 22, 1990, p. 469-485. Research supported by the Jordan University of Science and Technology. refs
(Contract NAG3-37)
Copyright

A model analysis approach is used to study the forced response of an actual flexible bladed-disk-shaft system. Both in-plane and out-of-plane flexible deformations of the bladed-disk assembly are considered, in addition to its rigid-body translations and rotations, resulting from the bending of the supporting flexible shaft in two orthogonal planes. The effects of Coriolis forces and structural coupling between flexible and rigid disk motions on the system's response are investigated. Aerodynamic loads acting on the rotating and vibrating bladed-disk assembly are accounted for through a simple quasi-steady representation, to evaluate their influence, combined with shaft flexibility and Coriolis effects. Author

A90-43763
THE PROPFAN . . . WHAT FUTURE NOW?
KEN FULTON Air International (ISSN 0306-5634), vol. 38, Feb. 1990, p. 59-64.
Copyright

Various propfan engine and research and development programs involving work undertaken by U.S., European, and Soviet industry are presented. In general, it appears that all the researchers involved in this effort are adopting more and more of a drift away from an early introduction of the propfan for commercial application. This results from the underlying problem that the development and production costs of new or even derivative propfan transports would make the aircraft too expensive for the commercial operators to back as long as the price of aviation fuel remains at its current level. In addition, it is probable that new, more efficient, aircraft designs may be needed in order to take full advantage of the propfan's large reduction in specific fuel consumption. The different approaches taken by the major international aircraft and engine manufacturers are discussed. R.E.P.

A90-44410* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MIXING AND COMBUSTION ENHANCEMENT IN SUPERSONIC REACTING FLOWS
J. PHILIP DRUMMOND, MARK H. CARPENTER, and H. S. MUKUNDA (NASA, Langley Research Center, Hampton, VA) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 1. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 175-184. refs
Copyright

Research has been conducted for a number of years at the NASA Langley Research Center to develop a supersonic combustion ramjet (scramjet) capable of propelling a vehicle at hypersonic speeds in the atmosphere or beyond. Recently, that research has been directed toward the optimization of the scramjet combustor, and in particular the efficiency of fuel-air mixing and reaction in the engine. This paper describes a study of fuel-air mixing and reaction in a supersonic flow field, and discusses several techniques that were applied for enhancing the mixing processes and overal combustion efficiency in the flow. Based on the results of the study, an alternate fuel injector configuration was computationally designed, and that configuration significantly increased the amount of fuel-air mixing and combustion over a given combustor length that was achieved. Author

A90-44594
WIDE-CHORD FAN PROVED IN NEARLY FIVE YEARS OF SERVICE
PHILIP RUFLES (Rolls-Royce, PLC, London, England) Rolls-Royce Magazine (ISSN 0142-9469), June 1989, p. 24-28.
Copyright

The wide-chord fan is a key component of high-bypass turbofan engines for jet airliners and has been incorporated into a number of advanced civil engines including the RB211-535E4 engine powering the Boeing 757 and the new RB211-524L scheduled for certification in 1992. Design, airflow, and thrust provided by the fan in various engines are discussed. It is noted that the 524G's fan rotates at up to 4,000 rpm, its blade tip speed is about 1,500 ft/sec, and that intake air approaches the blade tips at a relative speed of Mach 1.5. Snubber efficiency loss is outlined. Elimination of snubbers has been achieved through a wide-chord fan design. Blades are of sandwich construction with titanium alloy skins and a thin-walled honeycomb core also of titanium alloy. Improvements in performance, surge margin, specific fuel consumption, and overall design resulting from a wide-chord engine are outlined. It is noted

that the wide-core fan and common exhaust nozzle have both helped to reduce noise levels. L.K.S.

A90-44595
ADVANCED DEVELOPMENTS OF THE TURBO-UNION RB199
BRIAN MILLER (Rolls-Royce, PLC, Bristol, England) Rolls-Royce Magazine (ISSN 0142-9469), Dec. 1989, p. 7-12.
Copyright

Turbo-Union development of the RB199 continues and new roles are emerging for the RB199-powered aircraft, particularly the electronic combat and reconnaisance (ECR) Tornado. Improvement of RB199 technology could offer both higher engine performance to boost operational effectiveness and improvement in life-cycle costs of up to 40 percent. The latest Mk 105 version of the RB199 can provide a thrust increase to 16,800 lb in reheat for the Tornado ECR and a further version, the RB199-127, should give further increase in thrust with reheat. Component advances for the enhanced Mk 105, planned to be available in 1992, are discussed and improvements currently available are described including changes to the RB199 FADEC, incorporation of single-crystal turbine blades, and advanced HP turbine nozzle guide vanes. The general role of ECR aircraft and the U.S. requirement are discussed, noting that this version of the Tornado is suitable as a replacement for the F-4G Wild Weasel Phantoms used by the U.S. Air Force to seek and destroy the radar guidance systems of hostile weapons. L.K.S.

A90-44596
FUTURE DEVELOPMENT OF THE 535E4 ENGINE
BRUCE BOADEN (Rolls-Royce, PLC, London, England) Rolls-Royce Magazine (ISSN 0142-9469), March 1990, p. 22-24, 27.
Copyright

The features of the 535E4 engine and the continuing improvement planned for this widely used civil turbofan engine are surveyed. Emphasis is towards better fuel consumption, reduction in weight, and improved reliability. 535E4 design heritage is reviewed, and technical data and advanced design features which combine to provide low noise levels, good performance retention, high resistance to foreign object damage, high levels of reliability, and low operating costs are presented. The wide-core fan and the integrated final nozzle, cited as key features in the 535E4, are discussed in detail and performance and reliability rates are reviewed. A series of diagrams is included. L.K.S.

A90-44597
MORE POWER FOR THE HARRIER
BRIAN EVANS (Rolls-Royce, PLC, London, England) Rolls-Royce Magazine (ISSN 0142-9469), June 1990, p. 14-19.
Copyright

Improvements in engine technology for the Harrier are discussed. The Pegasus 11-61 engine provides 3,000 lb of extra thrust in tropical-day conditions and is scheduled to be installed in the U.S. Marine Corps' AV-8B Harrier IIs. The XG15 technology demonstrator program is cited as a basis for the Pegasus 11-61 program. Fan aerodynamics and the employment of single-crystal cast material for blading provided the main avenues available for *subsequent improvement of Pegasus performance. Constraints* posed by the incorporation of the engine into Harrier airframes such as fan length, nozzle size, and the front/rear nozzle thrust ratio are listed and their solutions discussed. These improvements in fan aerodynamics and material are explored, with particular attention to the redesign of disk assemblies and solutions to weight control problems. Results of flight testing and the low cost of ownership are discussed. L.K.S.

A90-44605
PROPULSION SYSTEMS FOR THE '90S
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 10, Aug. 1990, p. 17-20, 23, 24 (9 ff.).
Copyright

A review is presented of the aeroengine industry to determine who is building and utilizing the engines and what the important design parameters and operational factors are. In terms of acquisition, maintenance, and replacement, the propulsion system accounts for approximately two-thirds of a commercial aircraft's life cycle cost. For the military engine market, attention is focused on the USAF's ATF under its Increased Performance Engine (IPE) program, to incorporate greater performance and reliability into the candidate engines. Details are provided for the engines produced and under development by the major engine companies of the U.S.A., Western Europe, and Japan. Advanced technologies are continuing to have significant impact on the capabilities of aircraft propulsion systems. Internal computational fluid mechanics (ICFM) is one such development that is proving to be an effective tool in engine design. Continued improvement of ICFM will lead to a more efficient engine design process that will allow accurate quantitative tradeoffs between performance, structural design, and weight. Ducted propeller designs that may lead to ultrahigh-bypass-ratio trubofan engines are also discussed. R.E.P.

A90-44721
MATHEMATICAL SIMULATION MODEL OF AN AIRCRAFT GAS TURBINE [MATEMATICKY SIMULACNI MODEL LETECKE POHONNE JEDNOTKY SE SPALOVACI TURBINOU]
ZDENEK SCHINDLER, JAROSLAV DOLEZAL, JIRI FIDLER, and OLDRICH MATOUSEK Zpravodaj VZLU (ISSN 0044-5355), no. 2, 1990, p. 67-75. In Czech. refs
Copyright

A mathematical model of an aircraft gas turbine engine is presented. On the basis of physical relations, a system of nonlinear algebraic equations valid for the steady state regime of the unit is derived. A system of algebrodifferential equations is solved to simulate transition regimes. The method of solution proved to be very efficient and was implemented on several types of computers. It even comprises the possibility of optimizing the chosen design parameters of the unit. The model has been practically used when developing the M 602 unit. Author

A90-44726*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THREE-DIMENSIONAL TURBULENT FLOW CODE CALCULATIONS OF HOT GAS INGESTION
THOMAS J. VANOVERBEKE and JAMES D. HOLDEMAN (NASA, Lewis Research Center, Cleveland, OH) Journal of Aircraft (ISSN 0021-8669), vol. 27, July 1990, p. 577-582. Previously cited in issue 20, p. 3350, Accession no. A88-48752. refs
Copyright

A90-45301
MULTIVARIABLE OPTIMIZATION SCHEME FOR TUNING THE CONTROLLER OF AN ELECTRONIC FUEL CONTROL UNIT FOR SMALL GAS TURBINE ENGINES
G. CARRESE, A. I. GEORGANTAS, and T. KREPEC (Concordia University, Montreal, Canada) IN: Computers in engineering 1989; Proceedings of the ASME International Computers in Engineering Conference and Exposition, Anaheim, CA, July 30-Aug. 3, 1989. Volume 2. New York, American Society of Mechanical Engineers, 1989, p. 451-456.
Copyright

The tuning of the controller of an electronic fuel control unit for small gas turbine engines is formulated as a nonlinear programming problem. The fuel control unit studied, based on the Bendix DP-F2 unit, is adapted for electronic control by replacing the mechanical governor and pneumatic computing bellows by a stepper motor under microprocessor control. The automated test bench tuning procedure proposed converges rapidly to the optimum controller parameters. Author

A90-45414* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A REAL TIME MICROCOMPUTER IMPLEMENTATION OF SENSOR FAILURE DETECTION FOR TURBOFAN ENGINES
JOHN C. DELAAT and WALTER C. MERRILL (NASA, Lewis Research Center, Cleveland, OH) IEEE Control Systems Magazine

(ISSN 0272-1708), vol. 10, June 1990, p. 29-37. Previously announced in STAR as N89-29032. refs
Copyright

An algorithm was developed that detects, isolates, and accommodates sensor failures using analytical redundancy. The performance of this algorithm has been demonstrated on a full-scale F100 turbofan engine. The algorithm was implemented in real-time on a microprocessor-based controls computer which includes parallel processing and high order language programming. Parallel processing was used to achieve the required computational power for the real-time implementation. High order language programming was used in order to reduce the programming and maintenance costs of the algorithm implementation software. The sensor failure algorithm was combined with an existing multivariable control algorithm to give a complete control implementation with sensor analytical redundancy. The real-time microprocessor implementation of the algorithm, which resulted in the successful completion of the algorithm engine demonstration, is described.
Author

A90-45415
A MULTIPROCESSOR IMPLEMENTATION OF REAL-TIME CONTROL FOR A TURBOJET ENGINE
PHILLIP L. SHAFFER (GE Corporate Research and Development Center, Schenectady, NY) (1989 American Control Conference, Pittsburgh, PA, June 21-23, 1989) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 10, June 1990, p. 38-42. refs
Copyright

A real-time control program for a turbojet engine has been implemented on a four-processor computer, achieving a speedup of 3.38 times the speed of a sequential version of the same program on a single processor. The concurrent program was produced from a sequential program by subjecting the sequential program to global, hierarchical interprocedural data-flow analysis and timing measurements. A static schedule for the constituent tasks of the control program on the four processors was determined using a heuristic algorithm based on the critical-path method. The approach should be applicable to a variety of control and related programs where iterative tasks with well-bounded execution times are computed in systems with hard real-time requirements. I.E.

A90-45441
EHA LOADING ON THE 270-VDC BUS
RICHARD C. VAN NOCKER and HAROLD CARLSON (GE Aerospace, Philadelphia, PA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 8 p.
(SAE PAPER 892225) Copyright

Recent developments in the area of electrically driven actuators for primary flight control surfaces show that this technology will be applicable for the next-generation fighter aircraft. Architecture for the power-by-wire aircraft revolves around a 270-Vdc redundant (quad or triplex) distributed power bus with isolated avionics buses. Analysis and testing performed on a development 24-hp electrohydrostatic (EHA) system is described. Two 12-hp synchronous performance magnet motors driving fixed displacement pumps that drive a tandem actuator are used in this system. It is concluded that: (1) at zero speeds, the current free-wheels most of the time so that the current drawn from the 270-Vdc line is low; (2) during acceleration and deceleration periods, the 270-Vdc line current is low even though the motor phase current is high; and (3) in the case of regeneration, the statements above remain true, save that the currents are reversed.
R.E.P.

A90-45442
CONSIDERATIONS FOR SUCCESSFUL APPLICATION OF INTEGRATED DRIVE GENERATORS TO AIRCRAFT
EDWARD V. SCICCHITANO (Grumman Corp., Aircraft Systems Div., Bethpage, NY) and THOMAS D. YANIK (Sundstrand Advanced Technology Group, Rockford, IL) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 9 p.
(SAE PAPER 892226) Copyright

An account is given of the system integration aspects of the F-14D Super Tomcat's Integrated Drive Generator (IDG). The integration effort encompassed such questions as the accommodation of a continuous-speed drive in view of the F-14D's use of the F-110-GE-400 engine, whose diameter is larger than that of the original F-14A powerplant. The placement and configuration of the IDG's lubrication system, oil cooling system, thermal disconnect assembly, ram-air cooling system, built-in test equipment, etc, are considered in turn. Attention was given to the simplification of maintenance requirements throughout this effort.
O.C.

A90-45443
DESIGN FEATURES OF THE 747-400 ELECTRIC POWER SYSTEM
JIM THOM and JOHN FLICK (Sundstrand Corp., Rockford, IL) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 13 p.
(SAE PAPER 892227) Copyright

The B747-400 airliner's Electric Power System (EPS) has its basis in an integrated-drive generator and furnishes 360 kVA of 115-V three-phase ac power. The automatic noninterrupt-power transfer, load-management and selective-protection features of the EPS microprocessor-based control system result in a significant reduction of crew workloads, while also providing continuous advisory, status, and maintenance information to the cockpit displays. Power transfers without interruption reduce equipment utilization stresses and eliminate avionics power-up sequences following power transfers. EPS operational integrity is enhanced through the incorporation of built-in testing.
O.C.

A90-45444
VSCF CYCLOCONVERTER RELIABILITY REVIEW OF THE 30/40 KVA F/A-18 ELECTRICAL GENERATING SYSTEM
JOHN E. HAAG and CRAIG H. JENNINGS SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 9 p.
(SAE PAPER 892228) Copyright

The F/A-18 aircraft's variable speed/continuous frequency cycloconverter electrical generating system has accumulated over 1.5 million hours of field operation to date. The period of this system's intensive design was followed by modeling and prototype testing efforts; the aggressive program of environmental test screening located design and components weaknesses, and confirmed the ease of intermediate system level troubleshooting and repair which had been formulated as a major design goal. Throughout this test process, attention was given to both in-house burn-in failures and field failures, in order to identify potential weaknesses.
O.C.

A90-45454
APPLICATION CONSIDERATIONS FOR INTEGRAL GAS TURBINE ELECTRIC STARTER/GENERATOR REVISITED
EIKE RICHTER (GE Aircraft Engines, Cincinnati, OH) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 8 p. refs
(SAE PAPER 892252) Copyright

The application of advanced power electronics to the switched reluctance machine has led to the formulation of a viable approach to gas turbine integral starter/generator design. The resulting system furnishes acceptable power density, high temperature capability during high speed operation, good reliability, and exceptional operational capabilities under conditions of partial failure. The goal of further development of this technology is the creation of all-electric engine auxiliary systems. It is noted that a short-circuit is less likely to propagate in a switched-reluctance system than in a conventional one.
O.C.

A90-45455
POWER SYSTEM FOR 21ST CENTURY FIGHTER AIRCRAFT
R. M. KLAASS (Allied-Signal Aerospace Co., Garrett Auxiliary Power Div., Phoenix, AZ) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 8 p. refs

(Contract F33615-87-C-2807)
(SAE PAPER 892253) Copyright

To increase crew and aircraft survivability for 21st century fighters, a power system is envisioned which can supply higher power at high altitudes at the touch of a button. In the event of an aircraft power outage, this emergency power would be used to get the aircraft back under control and to restart the propulsion engines. The heart of the power system is a gas turbine, an Integrated Power Unit (IPU), designed to meet these requirements by starting and supplying 200 horsepower in two seconds, using a stored oxidizer (from air storage tanks on board the aircraft). The compressor is 'aerodynamically declutched' in this emergency power mode, minimizing the stored air needed by the IPU to supply the required power. In addition, the IPU can smoothly transition over to the normal air breathing mode, where the compressor supplies full flow and the stored air is not used at all. The size of the stored oxidizer supply is critical to establishing viability of this type of aircraft power system. This paper presents the results of the air bottle sizing study and concludes that a power system with reduced complexity, via the IPU concept, can significantly increase reliability, and reduce life cycle cost, at equivalent weight when compared to the latest power systems. Author

A90-45456
FAST START CERAMIC AUXILIARY POWER UNIT
TIBOR BORNEMISZA and COLIN RODGERS (Sundstrand Power Systems, San Diego, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 17 p. refs
(SAE PAPER 892254) Copyright

This paper discusses the results of analytical studies supported by current development efforts and research paths to implement fast-start technology for small gas turbine APUs, using nonmetallic rotor components. It is shown that both start system weight and rotor containment armor weight are proportional to the product of rotational speed squared and rotating assembly inertia. Significant weight savings are therefore feasible with rotating assemblies using lower density materials such as ceramics and composites. Recent tests are described wherein a modified T20 small gas turbine was accelerated from zero to 100 percent speed in 2.5 sec. Author

A90-45457
DESIGNING AND TUNING THE DIGITAL CONTROLLER OF AN ELECTRONIC FUEL CONTROL UNIT FOR SMALL GAS TURBINE ENGINES
ANTONIOS I. GEORGANTAS, GINO CARRESE, and TADEUSZ KREPEC (Concordia University, Montreal, Canada) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 13 p. refs
(SAE PAPER 892255) Copyright

To overcome some problems encountered in the design of electronic fuel control units for small gas turbine engines, different digital controllers are analyzed and implemented. A tuning method involving multivariable optimization techniques is formulated. The controllers are realized on a microcomputer which also monitors the experiments and performs the tuning on a specially equipped test bench. Author

A90-45476* Analytical Services and Materials, Inc., Hampton, VA.
NUMERICAL SIMULATION OF FLOW THROUGH THE LANGLEY PARAMETRIC SCRAMJET ENGINE
SHIVAKUMAR SRINIVASAN, PRADEEP S. KAMATH (Analytical Services and Materials, Inc., Hampton, VA), and CHARLES R. MCCLINTON (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 20 p. refs
(SAE PAPER 892314) Copyright

The numerical simulation of a three-dimensional turbulent, reacting flow through the entire Langley parametric scramjet engine has been obtained using a piecewise elliptic approach. The last section in the combustor has been analyzed using a parabolized Navier-Stokes code. The facility nozzle flow was analyzed as a first step. The outflow conditions from the nozzle were chosen as the inflow conditions of the scramjet inlet. The nozzle and the inlet simulation were accomplished by solving the three-dimensional Navier-Stokes equations with a perfect gas assumption. The inlet solution downstream of the scramjet throat was used to provide inflow conditions for the combustor region. The first two regions of the combustor were analyzed using the MacCormack's explicit scheme. However, the source terms in the species equations were solved implicitly. The finite rate chemistry was modeled using the two-step reaction model of Rogers and Chinitz. A complete reaction model was used in the PNS code to solve the last combustor region. The numerical solutions provide an insight of the flow details in a complete hydrogen-fueled scramjet engine module. Author

A90-45486
OPERATION OF THE ROLLS-ROYCE PEGASUS ENGINE ON LOW GRADE NON-AVIATION FUELS
ALBERT VENINGER (Rolls-Royce, Inc., Atlanta, GA) and LEO H. K. REED (Rolls-Royce, PLC, Bristol, England) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 15 p. refs
(SAE PAPER 892329) Copyright

An F402-RR-406A Pegasus Engine completed a sea level and altitude test program on a broad range of aviation and non-aviation fuels to highlight the fuel character effects on engine starting, handling, performance, gaseous emissions and smoke, hot section durability and AV-8B aircraft operation. The engine's abilities to start, handle, and perform were unimpaired by the range of fuels tested. The effects of using reduced quality alternative fuels, as characterized by lower hydrogen content, were centered mainly on the combustor section of the engine which experienced increases in smoke production, higher flame radiation and hotter metal temperatures, which could mean lower combustor durability. Fuel character effects on the engine were translated into operational impacts on the AV-8B Harrier Aircraft typical mission performance, which resulted in a small effect on payload/range capability. Author

A90-45511
THE USE OF THE CFM56 ENGINE IN THE KC-135 TANKER
G. A. AGRICOLA (CFM International, Inc., Cincinnati, OH) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 7 p.
(SAE PAPER 892362) Copyright

The use of a commercially designed and developed product for the installation and utilization in an existing military application offers new, interesting and fresh challenges. Aside from the normal minor tailoring and modification of the product required to meet the user's specifications, one must also consider variations in the standard maintenance and support patterns and procedures necessitated by the introduction of a commercial turbofan engine. However, the challenges were workable and solutions were established so that the use of the commercial CFM56 engine in this military KC-135 application has developed into a very successful marriage. Author

A90-45512
V2500 TURBOFAN ENGINE
STEPHEN J. NEMECEK (International Aero Engines AG, East Hartford, CT) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 7 p.
(SAE PAPER 892363) Copyright

The development history of the 25,000-lb thrust class V2500 turbofan employed by the A320-200 airliner, over the five years from its design to certification in 1989, is presented. Design objectives encompassed the lowest SFC in its thrust class, superior operating economics, lower noise and pollution levels, and modular design for low-cost maintenance. The V2500-powered A320-200 meets the FAR Part 36, Stage 3 and ICAO Annex 16 Chapter 3 noise limits, with a cumulative margin of 12.8 EPNdB. A 29,000-lb thrust member of the V2500 engine family is projected to be derivable in the near future with only a few changes to the engine's

core components; the additional thrust will be obtained with no increase in hot section temperatures. O.C.

A90-45513
THE RB211-535E4 - A COMMERCIALLY PROVEN ENGINE FOR THE MILITARY OF TOMORROW
ROGER S. CREEK (Rolls-Royce, Inc., Long Beach, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 16 p. refs
(SAE PAPER 892364) Copyright

Commercial off-the-shelf (COTS) acquisition of modern gas turbine propulsion units can offer significant advantages to the Military. In an environment where the requirements and demands are similar, as is the case for medium turbofan applications, then synergism with a commercial powerplant offers benefits in reliability, maintainability, capability and, above all, cost of ownership. The RB211-535E4 is a technology development from the highly derivative RB211 family, in the medium turbofan class. Since entering commercial serivce in 1984, the E4 is proving itself to be the most reliable medium turbofan engine in service today.
Author

A90-45514
THE PW2000 - A MATURE ENGINE WITH AN EYE TO THE FUTURE
ROBERT J. SAIA (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 10 p.
(SAE PAPER 892365) Copyright

Short- to medium-length airline routes require rugged engine designs. The PW2000 incorporates features to lower fuel consumption and provide superior durability and maintainability. A stiff centerline, erosion resistance of gas-path components, thermal resistance in the hot section, and FADEC control contribute to reliability and performance retention. Service experience demonstrates that the PW2000 has achieved early maturity. A product improvement plan will further increase reliability and lower operating costs.
Author

N90-25139# Rolls-Royce Ltd., Derby (England).
FROM 1959-1989: 30 YEARS OF SERVICE EXPERIENCE WITH RAMJETS
D. R. LANE 12 Mar. 1989 23 p Presented at RAes Conference, London, England, 12 Mar. 1989
(PNR90677; ETN-90-97158) Copyright Avail: NTIS HC A03/MF A01

Precautions taken during design of ramjets to achieve reliability and a low level of maintenance effort are described. In the third generation, design progressed to the establishment of wooden round status for a factory filled liquid fuel ramjet which requires no maintenance during a life of 15 years. The reliability of the ramjet propulsion system in many practice firings of service maintained missiles by service crews is discussed and shown to compare will that of solid fuel rocket systems.
ESA

N90-25982*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PERFORMANCE OF A SUPERCHARGED DIRECT-INJECTION STRATIFIED-CHARGE ROTARY COMBUSTION ENGINE
TIMOTHY A. BARTRAND (Sverdrup Technology, Inc., Brook Park, OH.) and EDWARD A. WILLIS Apr. 1990 25 p Presented at the Joint Symposium on General Aviation Systems, Ocean City, NJ, 11-12 Apr. 1990; sponsored in part by AIAA and FAA
(NASA-TM-103105; E-5430; NAS 1.15:103105) Avail: NTIS HC A03/MF A01 CSCL 21/5

A zero-dimensional thermodynamic performance computer model for direct-injection stratified-charge rotary combustion engines was modified and run for a single rotor supercharged engine. Operating conditions for the computer runs were a single boost pressure and a matrix of speeds, loads and engine materials. A representative engine map is presented showing the predicted range of efficient operation. After discussion of the engine map, a number of engine features are analyzed individually. These features are: heat transfer and the influence insulating materials have on engine performance and exhaust energy; intake manifold pressure oscillations and interactions with the combustion chamber; and performance losses and seal friction. Finally, code running times and convergence data are presented.
Author

N90-25985# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
GAS TURBINE COMBUSTION, VOLUME 1
1990 407 p Lecture series held in Rhode-Saint-Genese, Belgium, 19-23 Feb. 1990
(VKI-LS-1990-02-VOL-1; ISSN-0377-8312; ETN-90-97001) Avail: NTIS HC A18/MF A03

Combustor types, preliminary design and performance aspects, fuel injection and ignition, combustor cooling and emissions are discussed. Subsonic and supersonic combustion flow modeling are described. Sample calculations and comparisons with experimental data are shown and discussed. The physical phenomena and interactions in turbulent flames are described. Various models for premixed and nonpremixed flames are reviewed. Combustion chemistry is discussed. Special attention is given to better understanding laminar and turbulent combustion as well as pollutant formation. The instrumentation techniques used to characterize air, droplet or particle velocity flow fields is discussed. The role of data processing equipment in interpreting the data is demonstrated.

N90-25986# Cranfield Inst. of Tech., Bedford (England). School of Mechanical Engineering.
COMBUSTION IN THE GAS TURBINE. PART 1: COMBUSTOR TYPES AND DESIGN
RITI SINGH *In* VKI, Gas Turbine Combustion, Volume 1 9 p 1990
(CIT/SME/VKI/RS/1) Avail: NTIS HC A18/MF A03

The general design and performance of gas turbine engines are discussed. The performance requirements and the basic design features of a gas turbine combustion chamber are summarized. The types of combustion chamber and their relative merits are described. The reasons why tubular chambers are no longer specified for aeroengine designs are presented. The complex and heavy ducting needed between the compressor and the chambers and between the chambers and turbine makes tubular type engines both heavier and larger in diameter than tubo-annular or annular type combustion chambers. The advantages and disadvantages of the tubo-annular and annular type combustion chambers are presented. Illustrations of these combuster types are included.
ESA

N90-25987# Cranfield Inst. of Tech., Bedford (England). School of Mechanical Engineering.
COMBUSTION IN THE GAS TURBINE. PART 2: PRELIMINARY DESIGN AND PERFORMANCE
RITI SINGH *In* VKI, Gas Turbine Combustion, Volume 1 17 p 1990
(CIT/SME/VKI/RS/3) Avail: NTIS HC A18/MF A03

The function and sizing of combustion chamber components is addressed. Ways to determining the relative dimensions of diffuser, outer casing, and flame tube incorporating primary, intermediate and dilution zones are discussed. Formulas and diagrams used in calculating the dimensions of these various engine components are presented. Flame tube width and length are calculated. A detailed study of gas flow in the primary, intermediate and dilution zones of the flame tube is presented.
ESA

N90-25988# Cranfield Inst. of Tech., Bedford (England). School of Mechanical Engineering.
COMBUSTION IN THE GAS TURBINE. PART 3: FUEL INJECTION, IGNITION AND STABILITY
RITI SINGH *In* VKI, Gas Turbine Combustion, Volume 1 13 p 1990
(CIT/SME/VKI/RS/4) Avail: NTIS HC A18/MF A03

The basic role of the fuel injector in a gas turbine engine is

summarized. A table comparing the properties of different types of fuel injectors is presented. The notion of designing for stability in fuel injection and combustion chamber design is discussed. Engine ignition, especially high altitude relight performance is discussed. The fundamental aspects of the ignition process are listed. Ways of improving ignition performance are listed. A table listing solutions to failure to light on ground or at altitude is presented. Factors affecting the stability of combustion chambers are discussed. ESA

N90-25989# Cranfield Inst. of Tech., Bedford (England). School of Mechanical Engineering.
COMBUSTOR COOLING ASPECTS
RITI SINGH *In* VKI, Gas Turbine Combustion, Volume 1 78 p 1990
(CIT/SME/VKI/RS/5) Avail: NTIS HC A18/MF A03

Heat transfer processes in a gas turbine engine are discussed. Internal heat radiation and radiation from non luminous gases inside the engine is studied. The parts played by H2O, CO2 and N2 in the hydrocarbon flames are analyzed in detail. Radiation from luminous gases produced by the buildup of soot particles in the combustion chamber is discussed. When large buildup of soot particles occurs, severe radiant heating with its attendant problems of liner durability occurs. The influence of fuel composition on engine temperature is outlined. ESA

N90-25990# Cranfield Inst. of Tech., Bedford (England). School of Mechanical Engineering.
POLLUTANTS: PRODUCTION AND METHODS OF REDUCTION
RITI SINGH *In* VKI, Gas Turbine Combustion, Volume 1 60 p 1990
(CIT/SME/VKI/RS/6) Avail: NTIS HC A18/MF A03

The various components of gas turbine engine exhausts are analyzed in terms of their role as pollutants. The engine emissions identified as offering the greatest potential threat to the stratosphere are water vapor, carbon dioxide, sulfur compounds and nitric oxides. The mechanisms of pollutant formation are described. The production of carbon monoxide and unburned hydrocarbons due to incomplete combustion is described. The influence of fuel properties, pressure and temperature on emissions is discussed. Methods of pollution reduction are presented. ESA

N90-25991# Imperial Coll. of Science and Technology, London (England). Fluids Section.
SUBSONIC COMBUSTOR FLOW MODELING: STATE OF THE ART OF CFD TECHNIQUES FOR REACTING AND COMBUSTING FLOW
J. J. MCGUIRK *In* VKI, Gas Turbine Combustion, Volume 1 29 p 1990
Avail: NTIS HC A18/MF A03

Gas turbine models of subsonic flows which give reasonable predictions at reasonable computing cost are reviewed. The ability to handle the complex geometry of practical combustors, to predict details of internal flow structure, and exit temperature pattern factors make such models more accurate than those used ten years before. Almost all model elements, however, need further improvement. The prediction of pollutant emissions, and accurate wall temperatures in particular, requires combustion model improvement. ESA

N90-25992# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPERSONIC COMBUSTOR MODELING
DAVID W. RIGGINS, J. PHILIP DRUMMOND, and MARK H. CARPENTER *In* VKI, Gas Turbine Combustion, Volume 1 95 p 1990
Avail: NTIS HC A18/MF A03

The physical phenomena involved when a supersonic flow undergoes chemical reaction are discussed. Detailed physical models of convective and diffusive mixing, and finite rate chemical reaction in supersonic flow are presented. Numerical algorithms used to solve the equations governing these processes are introduced. Computer programs using these algorithms are used to analyze the structure of the reacting mixing layer. It is concluded that, as in subsonic flow, exothermic heat release in unconfined supersonic flows retards fuel/air mixing. Non mixing is shown to be a potential problem in reducing the efficiency of supersonic as well as subsonic combustion. Techniques for enhancing fuel/air mixing and combustion are described. ESA

N90-25993# Rouen Univ. (France). Faculte des Sciences.
TURBULENT COMBUSTION MODELING FOR TURBO-JET COMBUSTION CHAMBERS
R. BORGHI *In* VKI, Gas Turbine Combustion, Volume 1 42 p 1990
Avail: NTIS HC A18/MF A03

The size of the combustion chamber and the operating conditions chosen are taken into account in developing turbulent combustion models for turbojet engines. Premixed and non premixed conditions are discussed in terms of their integration in turbulence models. Computation of flame length and global heat release during normal engine operating conditions is shown to be accurate within 10 to 20 percent provided that one is sure of the turbulence values used. The need for improvement in the prediction of chemical reactions, particularly the production of pollutants, is called for. ESA

N90-25994# Stuttgart Univ. (Germany, F.R.). Inst. fuer Technische Verbrennung.
CHEMISTRY OF COMBUSTION PROCESSES
J. WARNATZ *In* VKI, Gas Turbine Combustion, Volume 1 50 p 1990 Sponsored by BMFT, CEE, Fonds der Chemischen Industrie, and Max-Buchner-Stiftung
Avail: NTIS HC A18/MF A03

Typical combustion processes are considered with emphasis on the basic physics and chemistry of combustion processes. Homogeneous reaction systems, the structure of laminar flame fronts for both stationary and instationary flame propagation and pollutant formation chemistry are discussed. Transport models, temperature and pressure dependance of reaction rate coefficients and the multiscale character of reaction systems are reviewed. High and low temperature chemical reaction mechanisms are described. Simulation of laminar premixed one-dimensional and two-dimensional combustion is presented. The detailed chemistry of turbulent combustion is discussed. ESA

N90-25995# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
GAS TURBINE COMBUSTION, VOLUME 2
1990 273 p Lecture series held in Rhode-Saint-Genese, Belgium, 19-23 Feb. 1990
(VKI-LS-1990-02-VOL-2; ISSN-0377-8312; ETN-90-97002) Avail: NTIS HC A12/MF A02

Combustion instrumentation designed to lower engine development and testing costs is described. Total and static pressure probes, low and high pressure thermocouples, holographic particle sizing and velocity systems and laser Doppler velocimeters are some of the instruments described. Supersonic and subsonic combustor testing are discussed in detail. Carbon slurry fuel spray characterization is described. Liquid-fuelled ramjet systems and concentric-dump ramburners are discussed. The history of hydrogen scramjet development and testing is described in detail. Supersonic mixing, fuel injector design and combustor diagnostics and performance are described.

N90-25997# United Technologies Research Center, East Hartford, CT. Propulsion Technology Group.
SUBSONIC COMBUSTOR TESTING
WILLIAM T. PESCHKE *In* VKI, Gas Turbine Combustion, Volume 2 75 p 1990
Avail: NTIS HC A12/MF A02

The development of a subsonic carbon slurry fuelled gas turbine engine is described. The carbon slurry fuels may offer significant improvement in volume limited flight vehicle applications. Atomization characteristics of the fuel are determined using a Malvern droplet sizer based on the Fraunhofer light diffraction

theory. Fuel spray patterns are documented by photographs using stroboscopic illumination with a twenty probe patternator rake. Three commercially available fuel injectors are tested. Flow visualization, flame spreading and stabilization, and testing procedure are described. The instrumentation used in the engine tests is described. The test results and lessons learned from the ramburner testing are outlined. ESA

N90-25999# Rolls-Royce Ltd., Derby (England).
APPLICATION OF HIGH PERFORMANCE METALS IN GAS TURBINE ENGINES
P. J. POSTANS 17 Oct. 1989 15 p Presented at the Metals Fight Back, London, England, 17 Oct. 1989
(PNR90640; ETN-90-97145) Copyright Avail: NTIS HC A03/MF A01

The development and application of two high performance gas turbine engine materials, Iml834 and Udimet 720 are described. These typify current approaches to alloy and microstructural development, component design, manufacture and life assessment. They illustrate how metals continue to expand their applications. Iml834 is a titanium alloy designed to operate at 600 C continuously with short excursions to 650 C, and is aimed at disc and blade operations in high performance compressors. Udimet 720 is a high strength 675 to 700 C capability nickel superalloy developed for high performance turbine discs. Material properties including tensile and creep strengths are described. ESA

N90-26000# Rolls-Royce Ltd., Derby (England).
TOWARDS 2000: THE COMPOSITE ENGINE
D. DRIVER 11 Nov. 1989 16 p Presented at the Australian Aeronautical Conference 1989 on Research and Technology: The Next Decade, Melbourne, Australia, 9-11 Oct. 1989
(PNR90646; ETN-90-97147) Copyright Avail: NTIS HC A03/MF A01

By the turn of the century aeroengine gas turbine temperatures are likely to approach 2000 C; thrust-to-weight ratios could reach 20:1 and turbofan thrusts exceed 80,000 lbs. Such advances will only be achieved with novel aeroengine designs which incorporate the higher specific strengths of polymeric, metal-matrix, and ceramic reinforced composite materials. The current state of materials and processing development for this range of aeroengine composite materials is reviewed. Conclusions are detailed. The designers and manufacturers face greater challenges than the materials developers. Three-dimensional design methodologies need to be developed to exploit the anisotropic nature of continuous/long fiber reinforced materials. ESA

N90-26001# Rolls-Royce Ltd., Derby (England). Theoretical Science Group.
PREDICTION OF ROTATING DISC FLOW AND HEAT TRANSFER IN GAS TURBINE ENGINES
JOHN W. CHEW Nov. 1989 17 p Presented at the 3rd International Symposium on Transport Phenomena and Dynamics of Rotating Machinery, Honolulu, Hawaii, Apr. 1990
(PNR90650; TSG0478; ETN-90-97148) Copyright Avail: NTIS HC A03/MF A01

Motivated by the need to improve design techniques for aeroengines considerable effort has been put into developing predictive techniques for rotating disc flow and heat transfer. Some notable recent advances are reviewed. The theoretical techniques employed include analytical solutions for laminar flow, momentum-integral methods for turbulent flow, and finite difference solutions of the Reynolds-averaged Navier-Stokes equations. Each of these methods is discussed and predictive capability is illustrated through comparisons with experimental data. ESA

N90-26002# Rolls-Royce Ltd., Derby (England). Aero-Engine Div.
PREDICTION AND MEASUREMENT OF ROTOR BLADE/STATOR VANE DYNAMIC CHARACTERISTICS OF A MODERN AERO-ENGINE AXIAL COMPRESSOR
R. J. WILLIAMS, K. L. JOHAL, H. A. BARTON, and S. T. ELSTON 3 Apr. 1989 8 p Presented at the Modern Practice in Stress and Vibration Analysis, Liverpool, England, 3-5 Apr. 1989
(PNR90667; ETN-90-97152) Copyright Avail: NTIS HC A02/MF A01

Commercial pressures require ever more fuel efficient and light weight propulsion systems. Inevitably this results in an increased stage loading that can exacerbate vibration problems of stall flutter, acoustic resonance, and conventional mechanical resonances from the immediate upstream and downstream blade/vane rows. The design of a rotor and stator from design to engine validation is traced. The components are analyzed at design stage using finite element models and modified to give acceptable dynamic characteristics. The predicted and measured results are compared and the method of assessment described. ESA

N90-26003# Rolls-Royce Ltd., Derby (England).
THE IMPACT AND REQUIREMENTS OF NEW MATERIALS ON AEROENGINES
G. E. KIRK 1 Mar. 1989 15 p Presented at the Royal Aeronautical Society Conference on Aerospace Application of Advanced Materials, 1 Mar. 1989
(PNR90671; ETN-90-97155) Copyright Avail: NTIS HC A03/MF A01

Future engine requirements, the status of major candidate materials and the problems that need to be solved before these materials can be incorporated with confidence are reviewed. Conclusions include: a requirement exists to reduce manufacturing cost by lower raw material cost and improved process control; resin composites need increased temperature capability, improved impact and resistance, coatings for erosion resistance and better repair procedures; advanced glass, metal and ceramic composites need improvements in fiber technology, coatings, the control of fiber matrix interface, and advanced fabrication techniques. ESA

N90-26004# Rolls-Royce Ltd., Derby (England).
AIRCRAFT EXHAUST EMISSIONS: AN ENGINE MANUFACTURER'S PERSPECTIVE
D. M. SNAPE 5 Feb. 1990 24 p Presented at the ICAA Seminar, Brussels, Belgium, 5-7 Feb. 1990
(PNR90675; ETN-90-97156) Copyright Avail: NTIS HC A03/MF A01

Exhaust emissions from an aircraft gas turbine are studied. Estimated emissions deposited into the atmosphere per passenger for a typical journey by car and by aircraft are compared. For this consideration, the duty of the combustor is studied and emissions characteristics shown. Potential benefits of improved combustion are outlined. A summary of the current position illustrates that while it is difficult to justify economically the need for further work on smoke, hydrocarbons and carbon monoxide, further progress is desirable on oxides of nitrogen and possibly carbon dioxide. These are considered in detail. ESA

N90-26005# Rolls-Royce Ltd., Derby (England).
THE APPLICATION OF ENGINEERING CERAMICS IN GAS TURBINES
G. SYERS 1 Mar. 1990 24 p Presented at the Hatfield Polytechnic Inst. of Mettallurgist Lecture, Hatfield, England, 28 Mar. 1990
(PNR90676; ETN-90-97157) Copyright Avail: NTIS HC A03/MF A01

The solution to problems concerning the supply of cooling air, for components whose temperatures increase with improved combustion in propulsion units, by the adoption of ceramic materials in either reinforced or monolithic forms is addressed. Ceramic materials offer a marked reduction in weight and the ability to operate at significantly higher temperatures than those currently experienced by the conventional superalloys without cooling. The use of ceramic materials in gas turbines has been investigated for a number of years. Investigations include microstructural engineering, materials characterization, manufacture and testing of experimental turbine blades, shroud rings and gas bearings etc. Aspects concerning these components are discussed. ESA

N90-26007# Royal Aerospace Establishment, Farnborough (England).
HANDBOOK OF UNCERTAINTY METHODOLOGY FOR ENGINE TESTING AT PYESTOCK (ENGLAND)
J. C. ASCOUGH 8 Nov. 1989 68 p
(RAE-TM-P-1179; BR112839; ETN-90-97068) Copyright Avail: NTIS HC A04/MF A01

Measurements of aircraft gas turbine engine performance in the altitude test facility are subject to a small amount of uncertainty resulting from a combination of precision (or random) errors and bias (or systematic) errors. The limits of the precision errors can be readily calculated by statistical analysis of the results measured during the engine tests. Bias limits are not directy observable in the test results, but can be predicted by a comprehensive assessment or all possible sources of error, which are propagated to the test results. These methods can be difficult to comprehend and apply and a handbook was written as a guide, not only for engine test staff, but also for their customers who need to be assured of the rigorous attention given to identifying and reducing measurement uncertainty. ESA

N90-26009*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HOT GAS INGESTION CHARACTERISTICS AND FLOW VISUALIZATION OF A VECTORED THRUST STOVL CONCEPT
ALBERT L. JOHNS, GEORGE H. NEINER, TIMOTHY J. BENCIC, JOSEPH D. FLOOD, KURT C. AMUEDO, THOMAS W. STROCK, and BEN R. WILLIAMS (McDonnell Aircraft Co., Saint Louis, MO.) 1990 22 p Presented at the International Powered Lift Conference, London, England, 29-31 Aug. 1990; sponsored by Royal Aeronautical Society
(NASA-TM-103212; E-5623; NAS 1.15:103212) Avail: NTIS HC A03/MF A01 CSCL 21/5

A 9.2 percent scale short takeoff and vertical landing (STOVL) hot gas ingestion model was designed and built by McDonnell Douglas Corporation (MCAIR) and tested in the NASA Lewis Research Center 9- by 15-Foot Low Speed Wind Tunnel (LSWT). Hot gas ingestion, the entrainment of heated engine exhaust into the inlet flow field, is a key development issue for advanced short takeoff and vertical landing aircraft. The Phase 1 test program, conducted by NASA Lewis and McDonnell Douglas Corporation, evaluated the hot ingestion phenomena and control techniques and Phase 2 test program which was conducted by NASA Lewis are both reported. The Phase 2 program was conducted at exhaust nozzles temperatures up to 1460 R and utilized a sheet laser system for flow visualization of the model flow field in and out of ground effects. Hot gas ingestion levels were measured for the several forward nozzle splay configurations and with flow control/lift improvement devices which reduced the hot gas ingestion. The model support system had four degrees of freedom, heated high pressure air for nozzle flow, and a suction system exhaust for inlet flow. The headwind (freestream) velocity for Phase 1 was varied from 8 to 90 kn, with primary data taken in the 8 to 23 kn headwind velocity range. Phase 2 headwind velocity varied from 10 to 23 kn. Results of both Phase 1 and 2 are presented. A description of the model, facility, a new model support system, and a sheet laser illumination system are also provided. Results are presented over a range of main landing gear height (model height) above the ground plane at a 10 kn headwind velocity. The results contain the compressor face pressure and temperature distortions, total pressure recovery, compressor face temperature rise, and the environmental effects of the hot gas. The environmental effects include the ground plane temperature and pressure distributions, model airframe heating, and the location of the ground flow separation. Results from the sheet laser flow visualization test are also shown. Author

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A90-43706#
ADA REAL-TIME GPS/INS SIMULATION APPROACH TO SYSTEM DEVELOPMENT
DAVID A. DESCH and JAMES J. HVIZD (United Technologies Corp., Advanced Systems Div., San Diego, CA) IN: Institute of Navigation Satellite Division, International Technical Meeting, 2nd, Colorado Springs, CO, Sept. 27-29, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 253-257. refs

A GPS/INS simulation, highlighting Ada-unique aspects of the design process is described, and the software development philosophy and systems integration methodology are discussed. A description of the GPS/INS system hardware design is provided. A software development approach, using CASE-based object-oriented design methods and the Ada programming language, is employed to create a real-time simulation of an integrated GPS/INS navigator for a low-cost tactical weapon. This simulation, having over 10,000 lines of Ada code, contains detailed models of a fiber optic gyro based inertial measurement unit, GPS space and user segments, Kalman filter, and navigation processing algorithms. R.E.P.

A90-44723
PROBLEMS IN THE SYNTHESIS OF ADVANCED AIRCRAFT CONTROL SYSTEMS [NEKTERE PROBLEMY ZE SYNTEZY MODERNICH SYSTEMU RIZENI LETADEL]
MILAN FALTUS Zpravodaj VZLU (ISSN 0044-5355), no. 3, 1990, p. 119-132. In Czech. refs
Copyright

Issues related to energy consumption, dynamic analysis, and safety and reliability are examined in connection with the developpment of advanced aircraft control systems. The fail-operational and fail-safe design philosophies are first considered. Fly-by-wire designs are then examined, with attention given to the provision of the necessary aerodynamic qualities and the ensuing control laws. Some examples of the automation of aircraft control systems are presented. B.J.

A90-44847#
THE INTEGRATED CONTROL OF A PROPULSION-AIRFRAME SYSTEM
RONALD A. PEREZ and OSITA D. I. NWOKAH (Purdue University, West Lafayette, IN) ASME, Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. 8 p. Research supported by General Motors Corp. and Purdue Research Foundation. refs
(ASME PAPER 89-WA/DSC-12)

The problem of improving the performance of an interconnected dynamical system, consisting of a turbo engine and an airframe, in the presence of destructive dynamical interactions is considered. Static forward loop and feedback controllers that minimize the overall interaction over a prespecified frequency range are proposed. The control system consists of two components: a simple precompensator to improve the interaction and a feedback controller to improve the performance. Even for very simple controller structures, significant improvement over previous integration shcemes is obtained. Author

A90-45134
AIAA ATMOSPHERIC FLIGHT MECHANICS CONFERENCE, PORTLAND, OR, AUG. 20-22, 1990, TECHNICAL PAPERS
Conference sponsored by AIAA. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, 485 p. For individual items see A90-45135 to A90-45177.
Copyright

The present conference on atmospheric flight mechanics discusses optimal multivehicle trajectories, optimal plane change

by low aerodynamic forces, an assessment of a proposed fighter agility metric, space transfer vehicle deceleration to planetary orbit, atmospheric effects on Martian aerocapture, thrust-law effects on longitudinal stability in hypersonic cruise, and self-induced roll oscillations of low aspect ratio rectangular wings. Also discussed are canard-wing vortex interactions at subsonic-through-supersonic speeds, optimal input design for aircraft parameter estimation using dynamic programming principles, the effect of windshear on airspeed during aircraft landing approach, aerodynamic considerations for aircraft radomes, unsteady flow separation over slender bodies at high angle-of-attack, optimal control system design for departure prevention, analyses of missile flights over various sea states, and the flying qualities of large aircraft. O.C.

A90-45139#
FLYING QUALITIES PROBLEMS OF AEROSPACE CRAFT
GOTTFRIED SACHS (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 43-53. refs
(AIAA PAPER 90-2804) Copyright

The present long-term dynamics treatment of flying qualities and control problems of hypersonic aerospacecraft notes the existence of specific dynamics characteristics which differ from the stability and control properties conventionally associated with aircraft flight quality requirements. A 'height mode' exists in addition to the phugoid, and deficiencies are found in current considerations of the connection between the prohibition of aperiodic instability and related control gradients in hypersonic flight. In the hypersonic regime, specific problems exist with respect to the simultaneous control of flight path and Mach number; these may have their basis in either the intrinsic dynamics of a vehicle or their control-augmentation systems. O.C.

A90-45140#
DESIGN OF FLIGHT CONTROL SYSTEMS TO MEET ROTORCRAFT HANDLING QUALITIES SPECIFICATIONS
WILLIAM L. GARRARD and EICHER LOW (Minnesota, University, Minneapolis) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 54-63. refs
(Contract DAAL03-36-K-0056)
(AIAA PAPER 90-2805) Copyright

This paper describes a methodology for the design of control laws for augmentation of helicopter handling qualities. The design procedure uses eigenstructure assignment techniques for the design of inner loop control laws which decouple roll, pitch and yaw rates and vertical velocity, provide appropriate bandwidths in all channels, and stabilize low frequency open loop instabilities. With the inner loops closed, the angular rates and vertical velocity responses to commands are approximated by four decoupled first order systems. Various response types such as attitude command attitude hold can then be easily realized by simple single loop feedbacks and feedforwards wrapped around these inner loops. Both time and frequency responses show that the closed loop helicopter provides excellent nominal performance in terms of insensitivity to gusts and tracking of pilot commands and achievement of desired response type characteristics (handling qualities). Stability robustness was investigated by approximating unmodeled rotor dynamics, actuators, sensors, filters, sampling and computational delays, etc. by a single time delay. The effect of this uncertainty on the system was evaluated using unstructured singular value techniques. Author

A90-45141#
UNIFIED FLYING QUALITIES CRITERIA FOR LONGITUDINAL TRACKING
D. J. WILSON, J. E. BUCKLEY, and D. R. RILEY (McDonnell Aircraft Co., Saint Louis, MO) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 64-74. refs
(AIAA PAPER 90-2806) Copyright

Two fixed-base piloted simulations were conducted to investigate variations in longitudinal tracking dynamics. Pilot evaluations were conducted using an air-to-air fine tracking task. Cooper-Harper Ratings and pilot comments from these evaluations were used to generate two flying qualities criteria. These new guidelines help define Level 1 longitudinal tracking requirements for fighter aircraft. The simulation data gathered during this experiment is also compared to existing flying qualities criteria to search for additional correlations. Criteria such as Gibson's drop back time, Bandwidth, and a pitch sensitivity criterion exhibited varying degrees of correlation with the simulation data. Some implementation considerations are also presented to illustrate that non-classical pitch dynamics may be required to attain Level I tracking over a wide flight envelope without sacrificing flying qualities during large amplitude maneuvering. Author

A90-45142*# *Kansas Univ., Lawrence.*
ASSESSMENT OF PROPOSED FIGHTER AGILITY METRICS
RANDALL K. LIEFER, JOHN VALASEK, DAVID P. EGGOLD, and DAVID R. DOWNING (Kansas, University, Lawrence) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 75-84. refs
(Contract NCC2-588)
(AIAA PAPER 90-2807) Copyright

This paper presents the results of an analysis of proposed metrics to assess fighter aircraft agility. A novel framework for classifying these metrics is developed and applied. A set of transient metrics intended to quantify the axial and pitch agility of fighter aircraft is evaluated with a high fidelity, nonlinear F-18 simulation. Test techniques and data reduction method are proposed, and sensitivities to pilot introduced errors during flight testing is investigated. Results indicate that the power onset and power loss parameters are promising candidates for quantifying axial agility, while maximum pitch up and pitch down rates are for quantifying pitch agility. Author

A90-45143#
TOWARD A THEORY OF AIRCRAFT AGILITY
EUGENE M. CLIFF, FREDERICK H. LUTZE, KLAUS H. WELL (Virginia Polytechnic Institute and State University, Blacksburg), and BRIAN G. THOMPSON IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 85-93. Research supported by DARPA. refs
(Contract F49620-87-C-0016)
(AIAA PAPER 90-2808) Copyright

A definition of an aircraft agility vector is given and the details for evaluating it are presented. This vector, which represents the time-rate of change of the forces acting on the aircraft, can be given in the usual axial, normal and lateral components. While the achieved value of the agility vector can be computed at any point along the flight-path, it is also possible to evaluate the set of achievable values. The construction of such sets is demonstrated from aerodynamic and propulsive data for a modern fighter. Furthermore, by examining the limits of available controls, extreme points in the agility set can be determined. Figures showing a locus of these extremes for the representative fighter aircraft are presented with indications of the limiting control. Suggestions are given on the use of such plots in design and in comparisons of competing aircraft. Author

A90-45144#
AN EXPERIMENTAL INVESTIGATION OF ROLL AGILITY IN AIR-TO-AIR COMBAT
MARK H. DRAJESKE and DAVID R. RILEY (McDonnell Aircraft Co., Saint Louis, Mo) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers.

Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 94-107. refs
(AIAA PAPER 90-2809) Copyright

In studying fighter aircraft agility, government and industry researchers have developed a multitude of agility measures of merit, called metrics, to define and measure agility. The premise of much of this previous work is that the available flying qualities parameters and performance measurands do not adequately specify agility for today's and tomorrow's tactical aircraft. A piloted air combat simulation was conducted to determine if a proposed roll agility metric, entitled Torsional Agility, defined roll agility better than two traditional measures of roll agility, maximum roll rate and roll mode time constant. The simulation also investigated the importance of increased specific excess power versus increased roll agility. Results from the simulation showed increased specific excess power had a very strong effect on overall air combat performance while increased roll agility had a secondary effect. Furtherore, improvements to the two traditional measures of roll agility appeared to be more tactically significant than the improvements to the proposed Torsional Agility metric. Author

A90-45151*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SELF-INDUCED ROLL OSCILLATIONS OF LOW-ASPECT-RATIO RECTANGULAR WINGS
DANIEL LEVIN (NASA, Ames Research Center, Moffett Field, CA) and JOSEPH KATZ (San Diego State University, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 165-172. refs
(Contract NCC2-458)
(AIAA PAPER 90-2811)

Experimental investigation of small aspect ratio rectangular wings mounted on a free-to-roll sting balance indicated that self-induced roll oscillations are possible when the aspect ratio of such wings is less than 0.5. The oscillations are probably driven by the periodic changes in the location and strength of the side edge vortices, as it has been shown for the 'wing rock' motion of delta wings, where similar changes in the leading edge vortex strength and position cause the roll oscillations. During the roll oscillation cycle the roll angle, normal force, and the side force were recorded and presented for three wings with aspect ratios of 0.25, 0.35, and 0.47. This data indicates that the lift loss during roll oscillations of rectangular wings is less than what was measured for similar delta wings. Also, the flow field of such slender rectangular wings at high angles of attack is more complicated due to the additional leading edge vortex, when compared with the flow field over slender delta wings. Author

A90-45152*# Notre Dame Univ., IN.
AN EXPERIMENTAL STUDY OF THE NONLINEAR DYNAMIC PHENOMENON KNOWN AS WING ROCK
A. S. ARENA, JR., R. C. NELSON (Notre Dame, University, IN), and L. B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 173-183. refs
(Contract NCA2-406)
(AIAA PAPER 90-2812) Copyright

An experimental investigation into the physical phenomena associated with limit cycle wing rock on slender delta wings has been conducted. The model used was a slender flat plate delta wing with 80-deg leading edge sweep. The investigation concentrated on three main areas: motion characteristics obtained from time history plots, static and dynamic flow visualization of vortex position, and static and dynamic flow visualization of vortex breakdown. The flow visualization studies are correlated with model motion to determine the relationship between vortex position and vortex breakdown with the dynamic rolling moments. Dynamic roll moment coefficient curves reveal rate-dependent hysteresis, which drives the motion. Vortex position correlated with time and model motion show a time lag in the normal position of the upward moving wing vortex. This time lag may be the mechanism responsible for the hysteresis. Vortex breakdown is shown to have a damping effect on the motion. Author

A90-45156# Stanford Univ., CA.
PARAMETER IDENTIFICATION OF LINEAR SYSTEMS BASED ON SMOOTHING
A. E. BRYSON (Stanford University, CA) and M. IDAN IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 238-248. Research supported by NASA and Advanced Rotorcraft Technology, Inc. refs
(AIAA PAPER 90-2800) Copyright

A parameter identification algorithm for linear systems is presented. It is based on smoothing test data with different sets of system model parameters. The smoothing pass through the data provides all the information needed to compute the gradients of the smoothing performance measure with respect to the parameters. The parameters are updated using a quasi-Newton procedure, until convergence is achieved. The advantage of this algorithm over standard maximum likelihood identification algorithms is the computational savings in calculating the gradient. This approach is extended to identify one set of parameters from several test runs. The performance of this algorithm is demonstrated in identifying the parameters of a linear model describing the rigid body dynamics of the DLR BO-105 research helicopter from flight test data. The identification results are presented and compared to recently published models using maximum likelihood and frequency-domain algorithms. The models presented are in good agreement with each other. Author

A90-45157*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
OPTIMAL INPUT DESIGN FOR AIRCRAFT PARAMETER ESTIMATION USING DYNAMIC PROGRAMMING PRINCIPLES
VLADISLAV KLEIN (NASA, Langley Research Center; George Washington University, Hampton, VA) and EUGENE A. MORELLI IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 249-259. refs
(Contract NCC1-29)
(AIAA PAPER 90-2801) Copyright

A new technique was developed for designing optimal flight test inputs for aircraft parameter estimation experiments. The principles of dynamic programming were used for the design in the time domain. This approach made it possible to include realistic practical constraints on the input and output variables. A description of the new approach is presented, followed by an example for a multiple input linear model describing the lateral dynamics of a fighter aircraft. The optimal input designs produced by the new technique demonstrated improved quality and expanded capability relative to the conventional multiple input design method. Author

A90-45158#
REASSESSMENT AND EXTENSIONS OF PILOT RATINGS WITH NEW DATA
DAVID G. MITCHELL and BIMAL L. APONSO (Systems Technology, Inc., Hawthorne, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 260-269. refs
(AIAA PAPER 90-2823) Copyright

The Cooper-Harper Handling Qualities Rating (HQR) scale is the standard metric for qualitative pilot evaluations of handling qualities. The HQR scale is ordinal, with certain inherent properties and limitations that must be recognized in the manipulation of HQRs. This paper recapitulates earlier work in converting the HQR scale to an interval scale that does not possess the same limitations. Recent piloted simulation data are then examined to assess the use of HQRs as if they were from an interval scale. Additional analysis of pilot performance in the simulation shows

that the HQR scale is effective in describing the relative rankings of aircraft in terms of both pilot performance and pilot compensation. Author

A90-45159*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A PILOT RATING SCALE FOR EVALUATING FAILURE TRANSIENTS IN ELECTRONIC FLIGHT CONTROL SYSTEMS
WILLIAM S. HINDSON, JEFFERY A. SCHROEDER (NASA, Ames Research Center, Moffett Field, CA), and MICHELLE M. ESHOW (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 270-284. refs
(AIAA PAPER 90-2827) Copyright

A pilot rating scale was developed to describe the effects of transients in helicopter flight-control systems on safety-of-flight and on pilot recovery action. The scale was applied to the evaluation of hardovers that could potentially occur in the digital flight-control system being designed for a variable-stability UH-60A research helicopter. Tests were conducted in a large moving-base simulator and in flight. The results of the investigation were combined with existing airworthiness criteria to determine quantitative reliability design goals for the control system. Author

A90-45160#
EFFECT OF WIND SHEAR ON THE AIRSPEED DURING THE AIRPLANE LANDING APPROACH
ROLAND J. WHITE IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 285-292. refs
(AIAA PAPER 90-2838) Copyright

Equations are presented to calculate the gust velocity along the landing flight path of an airplane due to the presence of wind shear. Based on this gust input data, airplane equations of motion are solved to determine the minimum airspeed developed during trimmed flight, along the landing flight path. The wind shear is represented by a tilted vortex pair, in two-dimensional flow. Here a longitudinal velocity ratio is defined, along with a selected vortex core radius. The non-linear gust velocities are then approximated by a broken line linear ramp gust to use as input gust data for the airplane equations of motion. From this the minimum airspeed is found along with the flight path position. Author

A90-45161#
DYNAMICS AND CONTROL OF MANEUVERABLE TOWED FLIGHT VEHICLES
J. E. COCHRAN, JR., M. INNOCENTI, T. S. NO, and A. THUKRAL (Auburn University, AL) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 293-304. refs
(AIAA PAPER 90-2841) Copyright

The problems of dynamically modeling and automatically controlling the motion of a small flight vehicle which is being towed by a much larger one are considered. Mathematical models of the components of the system, which include the towing aircraft, tow cable reel mechanism, tow cable, and target aerodynamics are described. The development of an autopilot for stability augmentation and maneuvering is discussed. An overview of the implementation of the models in a digital computer simulation program is provided and some typical numerical results obtained using the program are presented. Author

A90-45162*# Aeronautical Research Labs., Melbourne (Australia).
MEASUREMENTS OF PRESSURES ON THE WING OF AN AIRCRAFT MODEL DURING STEADY ROTATION
COLIN A. MARTIN, PETER J. GAGE (Department of Defence, Aeronautical Research Laboratory, Melbourne, Australia), RANDY S. HULTBERG (Bihrle Applied Research, Inc., Jericho, NY), and JAMES S. BOWMAN, JR. (NASA, Langley Research Center, Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 305-315. refs
(AIAA PAPER 90-2842) Copyright

An investigation has been conducted in the Spin Tunnel Facility at the NASA Langley Research Center to measure the pressures on the wing surfaces of a model of a Basic Training Aircraft during steady rotation. The tests were made to determine the nature of the wing pressure distribution during rotations typical of spin entry and steady spin. Comparisons are made between the forces and moments obtained from integrating the pressure field with those measured directly during rotary balance force tests. The results are also compared with estimates determined from a simple numerical model of the wing aerodynamic forces. Author

A90-45167#
OPTIMAL CONTROL SYSTEM DESIGN FOR DEPARTURE PREVENTION
FUYING GE and C. EDWARD LAN (Kansas, University, Lawrence) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 367-374. refs
(AIAA PAPER 90-2837) Copyright

Control system design for high departure resistance in maneuver at high angles of attack is considered through a versatile numerical optimizer coupled with analysis of flight dynamic responses. The design variables are determined by the optimizer which minimizes or maximizes a defined objective function related to the desirable maneuverability and departure resistance. The analysis is based on the dynamic responses which are obtained by numerically integrating the general flight dynamic equations with nonlinear aerodynamics. In the design process, the effects of aerodynamic and dynamic coupling are considered. The nonlinear simulation models for an F-5A and an F-16 are used to demonstrate the method by designing an aileron-rudder interconnect system and an angle-of-attack limiting system to enhance maneuver and prevent departure. The results indicate that the present method is simple and effective for designing control systems at high angles of attack. Author

A90-45174#
SIMULATING TURBULENCE AND GUSTS FOR HANDLING QUALITIES EVALUATION
DAVID B. LEGGETT, DAVID J. MOORHOUSE, and JAMES M. ZEH (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 445-455. refs
(AIAA PAPER 90-2845)

The 1980 MIL-F-8785C Flying Qualities Specification (FQS) incorporated an extensively revised atmospheric disturbance model which combined wind, windshear, turbulence, and gust modeling for low altitudes, as required for terminal-area operations. An account is presently given of the FQS-relevant lessons learned from a piloted simulation program conducted with the Large Amplitude Motion Aerospace Research Simulator. In general, it is found that FQS furnished much more realistic and demanding tasks, on whose bases simulated aircraft handling qualities can be assessed, than alternative formulations of handling criteria. O.C.

A90-45175#
LARGE AIRCRAFT FLYING QUALITIES REVISITED
R. T. MEYER and E. G. HUSBAND (Lockheed Aeronautical Systems Co., Marietta, GA) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 456-464. refs
(AIAA PAPER 90-2847) Copyright

There is a significant difference in the operational capabilities of large aircraft vs relatively small aircraft. It is, therefore, reasonable to expect the flying qualities of large aircraft to be significantly different from those of small aircraft. This paper attempts to point out a few areas where it has been recognized that the conventional flying qualities criteria - especially for the military - did not account for some significant differences in aircraft size. Specific areas that are discussed are: the short period frequency in the longitudinal mode; the time to bank in the lateral mode; and the permissible time delay for all axes. Some changes in military Opcriteria which have been made and their potential influence in aircraft design are discussed. An example of state of the art changes in flight controls for an older large - though not very large by present sizes - aircraft and its flying qualities in light of new criteria is also discussed. Author

A90-45176#
HANDLING QUALITIES RESEARCH AT THE FLIGHT RESEARCH LABORATORY, NAE/NRC, 1980 - 1990 AND BEYOND
STEWART W. BAILLIE (National Aeronautical Establishment, Flight Research Laboratory, Ottawa, Canada) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 465-472. refs
(AIAA PAPER 90-2848) Copyright

A summary of the handling qualities research performed at the Flight Research Laboratory, NAE/NRC, over the past 10 years is presented. Three major areas are discussed, the study of advanced military rotorcraft handling qualities requirements, the integration and development of 4-axis side-arm controllers for rotorcraft, and investigations regarding the expansion of rotorcraft IFR operations. Author

A90-45177#
LESSONS LEARNED FROM THE S/MTD PROGRAM FOR THE FLYING QUALITIES SPECIFICATION
DAVID J. MOORHOUSE (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 473-479. refs
(AIAA PAPER 90-2849)

The STOL and Maneuver Technology Demonstrator (S/MTD) program's test aircraft is an F-15 configured with both canards and two-dimensional thrust-vectoring/thrust-reversing nozzles, in order to achieve 1500-ft landing runs and shorter takeoffs than the conventional configuration of this fighter. An effort was made during the development of the S/MTD's Integrated Flight/Propulsion Control system to ascertain the degree to which test data deviated from the Flying Qualities Specification, MIL-F-7875C; this document is to be replaced by MIL-STD-1797, which reflects substantial lessons learned in the course of S/MTD flight tests. O.C.

A90-45330*# Minnesota Univ., Minneapolis.
OPTIMAL PATHS THROUGH DOWNBURSTS
YIYUAN ZHAO (Minnesota, University, Minneapolis) and A. E. BRYSON, JR. (Stanford University, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Sept.-Oct. 1990, p. 813-818. Previously cited in issue 23, p. 3621, Accession no. A89-52646. refs
(Contract NAG2-191)
Copyright

A90-45331*# Minnesota Univ., Minneapolis.
CONTROL OF AN AIRCRAFT IN DOWNBURSTS
YIYUAN ZHAO (Minnesota, University, Minneapolis) and A. E. BRYSON, JR. (Stanford University, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Sept.-Oct. 1990, p. 819-823. refs
(Contract NAG2-191)
Copyright

Guidance schemes are designed to approximate the optimal survival and optimal performance paths through downbursts, which were determined in the previous paper. Specifically, climb-rate command following is used to achieve performance, and altitude command following is used to enhance survivability. Nonlinear simulations are conducted to investigate the effects of the climb-rate command and altitude command. Takeoff flight is considered and full thrust is assumed. In a mild to moderate downburst, an aircraft can follow a constant, smaller-than-nominal climb rate without stall. Better survival capability is achieved by climbing at a lower rate accompanied by lower altitude, and vice versa. In a severe downbursts, the aircraft must descend to avoid stall. The farther it descends, the higher the survival capability, but the poorer the performance. If the downburst is very severe, the best strategy is to descend immediately to the lowest safe altitude. Since the intensity of a downbursts is hard to evaluate prior to penetration, it is advisable to keep a high airspeed. Therefore, use of the survival strategy is recommended that employs maximum thrust and allows the aircraft to descend to a safe minimum altitude immediately upon entering a downburst on takeoff. Author

A90-45332*# Georgia Inst. of Tech., Atlanta.
HELICOPTER TRIM WITH FLAP-LAG-TORSION AND STALL BY AN OPTIMIZED CONTROLLER
DAVID A. PETERS, MNAOUAR CHOUCHANE, and MARK FULTON (Georgia Institute of Technology, Atlanta) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Sept.-Oct. 1990, p. 824-834. Research supported by the U.S. Army. refs
(Contract NAG1-710)
Copyright

An autopilot is applied to helicopter rotor flap-lag-torsion equations to obtain the control settings for a trimmed flight condition. The rotor aerodynamic description includes a stage-space dynamic stall model for lift and for pitching moments. Thus, the rotor is trimmed for flight conditions in which significant stall and torsional deformations are present. The autopilot is extended to Q-bladed rotors by a series of time-delay terms. As a result, the optimum gains and time constants depend upon the number of blades as well as upon the torsional stiffness. Author

A90-45333*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SYSTEM IDENTIFICATION REQUIREMENTS FOR HIGH-BANDWIDTH ROTORCRAFT FLIGHT CONTROL SYSTEM DESIGN
MARK B. TISCHLER (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Sept.-Oct. 1990, p. 835-841. refs
Copyright

The application of system identification methods to high-bandwidth rotorcraft flight control system design is examined. Flight test and modeling requirements are illustrated using flight test data from a BO-105 hingeless rotor helicopter. The proposed approach involves the identification of nonparametric frequency-response models followed by parametric (transfer function and state space) model identification. Results for the BO-105 show the need for including coupled body/rotor flapping and lead-lag dynamics in the identification model structure to allow the accurate prediction of control system bandwidth limitations. Lower-order models are useful for estimating nominal control system performance only when the flight data used for the identification are band-limited to be consistent with the frequency range of applicability of the model. The flight test results presented in this paper are consistent with theoretical studies by previous researchers. Author

A90-45334*# Systems Control Technology, Inc., Palo Alto, CA.
MAXIMUM LIKELIHOOD TUNING OF A VEHICLE MOTION FILTER
THOMAS L. TRANKLE and URI H. RABIN (Systems Control

Technology, Inc., Palo Alto, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Sept.-Oct. 1990, p. 842-849. Research supported by the Maritime Administration. refs
(Contract NAS2-11391; N00024-80-C-5375; N00421-85-D-0155)
Copyright

This paper describes the use of maximum likelihood parameter estimation unknown parameters appearing in a nonlinear vehicle motion filter. The filter uses the kinematic equations of motion of a rigid body in motion over a spherical earth. The nine states of the filter represent vehicle velocity, attitude, and position. The inputs to the filter are three components of translational acceleration and three components of angular rate. Measurements used to update states include air data, altitude, position, and attitude. Expressions are derived for the elements of filter matrices needed to use air data in a body-fixed frame with filter states expressed in a geographic frame. An expression for the likelihood functions of the data is given, along with accurate approximations for the function's gradient and Hessian with respect to unknown parameters. These are used by a numerical quasi-Newton algorithm for maximizing the likelihood function of the data in order to estimate the unknown parameters. The parameter estimation algorithm is useful for processing data from aircraft flight tests or for tuning inertial navigation systems. Author

A90-45335#
NONLINEAR FLIGHT CONTROL DESIGN VIA SLIDING METHODS
J. KARL HEDRICK (California, University, Berkeley) and SWAMINATHAN GOPALSWAMY Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Sept.-Oct. 1990, p. 850-858. refs
Copyright

Nonlinear inversion/sliding control techniques are applied to design a pitch axis control system for high-performance aircraft. The control objectives are to track pilot g commands while satisfying flying quality specifications. In the pitch axis problem, the dominant nonlinearities are the aerodynamic coefficients variation with angle of attack and saturation of the actuators position and rate response. Two design approaches are investigated; the first defines a single output to be controlled (pilot's normal acceleration) and coordinates the elevator and the flaperon as a single input. The nonminimum phase nature of the resulting input/output pair necessitates defining a modified output to avoid stability problems inherent in inversion methods. The second approach defines a two input/two output problem and directly incorporates the flying quality specifications into the output definition. These two methods are illustrated using a simulation model. The latter approach is shown to allow more freedom to avoid actuator saturation at high g commands.
Author

A90-45344*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTIMAL AUTOROTATIONAL DESCENT OF A HELICOPTER WITH CONTROL AND STATE INEQUALITY CONSTRAINTS
ALLAN Y. LEE (JPL, Pasadena, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Sept.-Oct. 1990, p. 922-924. refs
(Contract NCC2-106)
Copyright

A point-mass model of the OH-58A helicopter has been used to ascertain the autorotation profiles which minimize helicopter impact velocity while remaining within the bounds of the main rotor's collective pitch and angular speed. The optimal control strategies are comparable to those employed by pilots in autorotational landings. It is noted that a possibility exists for the reduction of the height-sink rate restriction zone of OH-58A helicopters, using optimal energy-management techniques. O.C.

A90-45413
AN EXPLICIT MODEL-MATCHING APPROACH TO LATERAL-AXIS AUTOPILOT DESIGN
K. DEAN MINTO (GE Corporate Research and Development Center, Schenectady, NY), JOE H. CHOW, and JAN W. BESELER (Rensselaer Polytechnic Institute, Troy, NY) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 10, June 1990, p. 22-28. refs
Copyright

The application of a linear multivariable control law design methodology to an autopilot design for large transport aircraft is described. The design method is an explicit model-matching approach, whereby compensator parameters are tuned via a least-squares optimization approach to minimize the error between the desired and the actual closed-loop frequency responses. This method incorporates some recent theoretical advances, including controller parametrization and plant factorization, and has been implemented within the ISICLE software package, a MATLAB-based control design toolbox. A desirable feature of the ISICLE design software is the capability to constrain the compensator dynamic order and structure, issues motivated by the necessity for low complexity implementations in order to simplify gain scheduling and limit protection. I.E.

A90-45437
FOREBODY VORTEX MANIPULATION FOR AERODYNAMIC CONTROL OF AIRCRAFT AT HIGH ANGLES OF ATTACK
G. N. MALCOLM and T. T. NG (Eidetics International, Inc., Torrance, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 25 p. refs
(Contract F33615-86-C-3623)
(SAE PAPER 892220) Copyright

Control of forebody vortices on fighter aircraft to generate yawing moments at high angles of attack has been investigated with wind tunnel tests on a generic fighter model. Simultaneous force and moment measurements on the complete configuration and the isolated forebody were obtained. Individually controlled tip strakes and pneumatic surface jets were both evaluated. The magnitude and direction of the yawing moment can be controlled by regulating the asymmetric deployment of the strakes or by differential blowing rates from the jets. Various strake sizes and locations were investigated. Strakes at 105 deg from windward were very effective for eliminating naturally asymmetric vortices and generating controllable yawing moments. Blowing jets aligned tangential to the surface in either aft or forward directions at 135 deg from windward were also very effective. The best method for controlling the yawing moment is to minimize the natural forebody vortex asymmetry with a small pair of tip strakes and utilize blowing to drive the yawing moment away from the symmetric condition.
Author

A90-45438* Vigyan Research Associates, Inc., Hampton, VA.
VORTEX CONTROL FOR TAIL BUFFET ALLEVIATION ON A TWIN-TAIL FIGHTER CONFIGURATION
DHANVADA M. RAO, C. K. PURAM (Vigyan Research Associates, Inc., Hampton, VA), and GAUTAM H. SHAH (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 20 p. refs
(SAE PAPER 892221) Copyright

Two aerodynamic concepts proposed for alleviating high-alpha tail buffet characteristics of a LEX (Leading Edge Extension) vortex dominated twin-tail fighter configuration were explored in low-speed tunnel tests on generic models via flow visualizations, 6-component balance measurements and monitoring of tail dynamics. Passive dorsal-fin extensions of the vertical tails, and an active LEX arrangement with up-deflected edge sections were evaluated as independent means of re-structuring the adverse vortical flow environment in the tail region. Each of these techniques successfully reduced the buffet as measured by the root-mean-square of tail accelerometer output, particularly at post-stall angles of attack when the baseline configuration was characterized by high buffet intensity. Used in combination, the two concepts indicated significant tail buffet relief with relatively minor impact on the high-alpha configuration aerodynamics.
Author

A90-45464* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SIMULATION EVALUATION OF TRANSITION AND HOVER FLYING QUALITIES OF A MIXED-FLOW, REMOTE-LIFT STOVL AIRCRAFT
JAMES A. FRANKLIN, MICHAEL W. STORTZ, SHAWN A. ENGELLAND, GORDON H. HARDY, JAMES L. MARTIN (NASA, Ames Research Center, Moffett Field, CA) et al. SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 21 p. refs
(SAE PAPER 892284) Copyright

Using a generalized simulation model developed for piloted evaluations of STOVL aircraft, an initial fixed-base simulation of a mixed-flow, remote-lift configuration has been completed. Objectives were to evaluate the integration of the aircraft's flight and propulsion controls to achieve good flying qualities throughout the low-speed flight envelope; to determine control power used during transition, hover, and vertical landing; and to evaluate the transition flight envelope considering the influence of thrust deflection of the remote-lift component. Pilots' evaluations indicated that Level 1 flying qualities could be achieved for deceleration to hover in instrument conditions, for airfield landings, and for recovery to a small ship when attitude and velocity stabilization and command augmentation control modes were provided. Level 2 flying qualities were obtained for these same tasks when only the attitude command mode was used, leaving the pilot to perform the task of thrust management required to control the flight-path and speed in transition and the horizontal and vertical translational velocities in hover. Thrust margins were defined for vertical landing as a function of ground effect and hot-gas ingestion. Author

A90-45475* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STABILITY CHARACTERISTICS OF A CONICAL AEROSPACE PLANE CONCEPT
DAVID E. HAHNE, JAMES M. LUCKRING, PETER F. COVELL, W. PELHAM PHILLIPS, GREGORY M. GATLIN (NASA, Langley Research Center, Hampton, VA) et al. SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 21 p. refs
(SAE PAPER 892313) Copyright

Data on stability characteristics of a conical aerospace plane concept were collected for a number of model geometry variations and test conditions, using several NASA-Langley wind tunnels spanning Mach range 0.1-6. The baseline configuration of this plane concept incorporated a 5-deg cone forebody, a 75.96-deg delta wing, a 16-deg leading-edge sweep deployable canard, and a centerline vertical tail. The key results pertinent to stability considerations about all three axes of the model are presented together with data on the effect of the canard on pitch stability, the effect of vertical tail on lateral-directional stability, and the effect of forebody geometry on yaw asymmetries. The experimental stability data are compared with the results from an engineering predictive code. I.S.

N90-25140# Lockheed Aeronautical Systems Co., Burbank, CA.
MODELING FLEXIBLE AIRCRAFT FOR FLIGHT CONTROL DESIGN Interim Report, Sep. 1986 - Mar. 1988
E. C. BEKIR, W. J. DAVIS, A. GOFORTH, H. HASSIG, E. J. HOROWITZ, R. N. MOON, and G. A. WATTS Jan. 1989 433 p
(Contract F33615-86-C-3625; AF PROJ. 2403)
(AD-A219123; AFWAL-TR-88-3089) Avail: NTIS HC A19/MF A03 CSCL 01/3

Trends to lower structural fraction of aircraft increase flexibility effects. Higher bandwidth control systems combined with these more flexible structures cause more aeroservoelastic interactions. Active, closed loop control systems allow greater flexibility. To take advantage of this design possibility, an integrated ASE model is needed for conceptual and preliminary design stages of aircraft. The equations of motion of a flexible aircraft from first principles are defined to aid future discussions between experts in the specialties which make up ASE: aerodynamics, controls, and structures. The development of the equations is documented, and conditions are stated under which the assumptions approximations are accurate. Five sections are given on different technical areas along with a summary: (1) Linearization of flexible aircraft hybrid-coordinate dynamic equations and inclusion of aerodynamic and gravitational loads; (2) Derivation of equations of motion and stability derivatives for a flexible aircraft vehicle; (3) Aerodynamics for aeroservoelasticity; (4) Model-order reduction for linear systems; and (5) Hydraulic actuator eqautions for aeroservoelastic modeling. Author

N90-25141*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
GROUND-SIMULATION INVESTIGATIONS OF VTOL AIRWORTHINESS CRITERIA FOR TERMINAL-AREA OPERATIONS
J. V. LEBACQZ, W. A. DECKER, T. S. ALDERETE, B. C. SCOTT, P. J. G. HARPER, and W. W. CHUNG (SYRE Corp., Moffett Field, CA.) May 1990 18 p Presented at the Royal Aeronautical Society Meeting: Progress in Helicopter and V/STOL Aircraft Simulation, London, England, 1-2 May 1990
(NASA-TM-102810; A-90129; NAS 1.15:102810) Avail: NTIS HC A03/MF A01 CSCL 01/3

Several ground-based simulation experiments undertaken to investigate concerns related to tilt-rotor aircraft airworthiness were conducted. The experiments were conducted on the National Aeronautics and Space Administration (NASA) Ames Research Center's Vertical Motion Simulator, which permits simulation of a wide variety of aircraft with a high degree of fidelity of motion cueing. Variations in conversion/deceleration profile, type of augmentation or automation, level of display assistance, and meteorological conditions were considered in the course of the experiments. Certification pilots from the Federal Aviation Administration (FAA) and the Civil Aviation Authority (CAA) participated, in addition to NASA research pilots. The setup of these experiments on the simulator is summarized, and some of the results highlighted. Author

N90-25142*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
EFFECTS OF SIMPLIFYING ASSUMPTIONS ON OPTIMAL TRAJECTORY ESTIMATION FOR A HIGH-PERFORMANCE AIRCRAFT
LURA E. KERN, STEVE D. BELLE (PRC Systems Services Co., Edwards, CA.), and EUGENE L. DUKE Apr. 1990 27 p Presented at the AIAA Atmospheric Flight Mechanics Conference, Boston MA, 14-16 Aug. 1989
(NASA-TM-101721; H-1597; NAS 1.15:101721) Avail: NTIS HC A03/MF A01 CSCL 01/3

When analyzing the performance of an aircraft, certain simplifying assumptions, which decrease the complexity of the problem, can often be made. The degree of accuracy required in the solution may determine the extent to which these simplifying assumptions are incorporated. A complex model may yield more accurate results if it describes the real situation more thoroughly. However, a complex model usually involves more computation time, makes the analysis more difficult, and often requires more information to do the analysis. Therefore, to choose the simplifying assumptions intelligently, it is important to know what effects the assumptions may have on the calculated performance of a vehicle. Several simplifying assumptions are examined, the effects of simplified models to those of the more complex ones are compared, and conclusions are drawn about the impact of these assumptions on flight envelope generation and optimal trajectory calculation. Models which affect an aircraft are analyzed, but the implications of simplifying the model of the aircraft itself are not studied. The examples are atmospheric models, gravitational models, different models for equations of motion, and constraint conditions. Author

N90-25143*# Sikorsky Aircraft, Stratford, CT.
GROUND SHAKE TEST OF THE UH-60A HELICOPTER AIRFRAME AND COMPARISON WITH NASTRAN FINITE ELEMENT MODEL PREDICTIONS Final Report
G. R. HOWLAND, J. A. DURNO, and W. J. TWOMEY Mar. 1990 236 p
(Contract NAS1-17499)
(NASA-CR-181993; NAS 1.26:181993) Avail: NTIS HC A11/MF A02 CSCL 01/3

Sikorsky Aircraft, together with the other major helicopter airframe manufacturers, is engaged in a study to improve the use of finite element analysis to predict the dynamic behavior of helicopter airframes, under a rotorcraft structural dynamics program called DAMVIBS (Design Analysis Methods for VIBrationS), sponsored by the NASA-Langley. The test plan and test results are presented for a shake test of the UH-60A BLACK HAWK helicopter. A comparison is also presented of test results with results obtained from analysis using a NASTRAN finite element model. Author

N90-25144*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLIGHT-TESTING OF THE SELF-REPAIRING FLIGHT CONTROL SYSTEM USING THE F-15 HIGHLY INTEGRATED DIGITAL ELECTRONIC CONTROL FLIGHT RESEARCH FACILITY
JAMES F. STEWART and THOMAS L. SHUCK Aug. 1990 17 p Prsented at the AIAA/SFTE/DGLR/SETP 5th Biannual Flight Test Conference, Ontario, CA, 21-24 May 1990 Previously announced in IAA as A90-34149
(NASA-TM-101725; H-1635; NAS 1.15:101725; AIAA-90-1321) Avail: NTIS HC A03/MF A01 CSCL 01/3

Flight tests conducted with the self-repairing flight control system (SRFCS) installed on the NASA F-15 highly integrated digital electronic control aircraft are described. The development leading to the current SRFCS configuration is highlighted. Key objectives of the program are outlined: (1) to flight-evaluate a control reconfiguration strategy with three types of control surface failure; (2) to evaluate a cockpit display that will inform the pilot of the maneuvering capacity of the damage aircraft; and (3) to flight-evaluate the onboard expert system maintenance diagnostics process using representative faults set to occur only under maneuvering conditions. Preliminary flight results addressing the operation of the overall system, as well as the individual technologies, are included. Author

N90-26010# National Aeronautical Lab., Bangalore (India). Flight Mechanics and Controls Div.
MODEL FOLLOWING CONTROL SYSTEM DESIGN: PRELIMINARY ATTAS IN-FLIGHT SIMULATION TEST RESULTS
SHYAM CHETTY and F. HENSCHEL Feb. 1990 48 p
(PD-FC-9003) Avail: NTIS HC A03/MF A01

The preliminary Advanced Technologies Testing Aircraft System (ATTAS) inflight simulation flight test results of the model following flight control system are described. A major portion of the current effort was directed towards estimating the time delays in the various control loop segments and incorporating these estimates in the controller design process and ground simulation software. Author

N90-26011*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
H-INFINITY BASED INTEGRATED FLIGHT-PROPULSION CONTROL DESIGN FOR A STOVL AIRCRAFT IN TRANSITION FLIGHT
SANJAY GARG, DUANE L. MATTERN (Sverdrup Technology, Inc., Brook Park, OH.), MICHELLE M. BRIGHT, and PETER J. OUZTS Aug. 1990 32 p Presented at the Guidance, Navigation and Control Conference, Portland, OR, 20-22 Aug. 1990; sponsored in part by AIAA
(NASA-TM-103198; E-5594; NAS 1.15:103198) Avail: NTIS HC A03/MF A01 CSCL 01/3

Results are presented from an application of H-infinity control design methodology to a centralized integrated flight/propulsion control (IFPC) system design for a supersonic Short Take-Off and Vertical Landing (STOVL) fighter aircraft in transition flight. The overall design methodology consists of a centralized IFPC controller design with controller partitioning. Only the feedback controller design portion of the methodology is addressed. Design and evaluation vehicle models are summarized, and insight is provided into formulating the H-infinity control problem such that it reflects the IFPC design objectives. The H-infinity controller is shown to provide decoupled command tracking for the design model. The controller order could be significantly reduced by modal residualization of the fast controller modes without any deterioration in performance. A discussion is presented of the areas in which the controller performance needs to be improved, and ways in which these improvements can be achieved within the framework of an H-infinity based linear control design. Author

N90-26012# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.
TECHNICAL EVALUATION REPORT ON THE GUIDANCE AND CONTROL PANEL 49TH SYMPOSIUM ON FAULT TOLERANT DESIGN CONCEPTS FOR HIGHLY INTEGRATED FLIGHT CRITICAL GUIDANCE AND CONTROL SYSTEMS
BERNARD CHAILLOT (Direction des Recherches, Etudes et Techniques, Paris, France) May 1990 21 p Symposium held in Toulouse, France, 10-13 Oct. 1989
(AGARD-AR-281; ISBN-92-835-0559-X) Copyright Avail: NTIS HC A03/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Twenty-three papers were presented at the Guidance and Control Panel 49th Symposium including the keynote address, covering the following headings; trends in integrated flight critical systems; advanced fault tolerant design concepts; system architectures, mechanization, and integration issues; high integrity software design methodologies and algorithms; and system validation, simulation, and flight test experience. Author

N90-26014# Loughborough Univ. of Technology (England). Dept. of Mathematical Sciences.
AN INVESTIGATION OF THE USE OF SINGULAR PERTURBATION METHODS AND MODAL CONTROL THEORY IN THE DERIVATION OR AIRCRAFT CONTROL SCHEMES
S. K. SPURGEON 1989 37 p
(MATHS-REPT-A-106; ETN-90-97122) Avail: NTIS HC A03/MF A01

Two techniques which extend control design philosophies based upon pole-placement are considered. Singular perturbation theory, to provide desirable asymptotic system behavior, and direct eigenstructure assignment, to specify the desired dynamic response of the system are used. The underlying theory behind these methods is described. The two design philosophies are compared. The development of an advanced longitudinal multi-mode scheme for a dynamically unstable aircraft is considered. ESA

N90-26015# Institut Franco-Allemand de Recherches, Saint-Louis (France).
MANEUVERING BY MEANS OF LATERAL JETS [STEUERUNG MITTELS SEITLICH AUSTRETENDER STRAHLEN]
K. W. NAUMANN 29 Dec. 1989 55 p In GERMAN Presented at CCG-Lehrgang B2.19 der Carl-Granz-Gessellschaft, Weil am Rhein, Fed. Republic of Germany, 21-24 Nov. 1988
(ISL-CO-255/88; ETN-90-97021) Avail: NTIS HC A04/MF A01

Piloting techniques by means of lateral jets during hypersonic flight are discussed. The jets cause important perturbations of the air flow around the vessel. These perturbations can increase or decrease the overall thrust. Methods of finding a compromise between favorable interactions, and parasitic effects decreasing the flight stability of the vessel are presented. The goal of the research is to provide engineers with appropriate methods and data for accurate calculation of piloting parameters. An extensive

bibliography is included to help engineers in developing lateral jet guidance systems. ESA

N90-26016# Aeritalia S.p.A., Turin (Italy). Flight Test Dept.
AM-X HIGH INCIDENCE TRIALS, DEVELOPMENT AND RESULTS
G. MENSO and B. MARCHETTO 1989 10 p Presented at 20th Society of Flight Test Engineers Annual Symposium, Reno, NV, 18-21 Sep. 1989
(ETN-90-97277) Avail: NTIS HC A02/MF A01

The activities carried out to investigate the high angle of attack/spin characteristics of the AM-X are described. Vertical wind tunnel and rotary balance facilities were used to collect all the information on aircraft behavior at stall, beyond stall, and in developed spin required to efficiently approach the flight test activity. A special training of the ground monitoring team and adequate use of the telemetry facilities allowed the efficient employment of flight time. Analysis of the test results allowed validation and identification of the aerodynamics model. Flight controls modifications useful to improve the aircraft behavior at high incidence are suggested. ESA

N90-26017*# North Carolina State Univ., Raleigh. Dept. of Mechanical and Aerospace Engineering.
LOW-SPEED WIND TUNNEL INVESTIGATION OF THE STATIC STABILITY AND CONTROL CHARACTERISTICS OF AN ADVANCED TURBOPROP CONFIGURATION WITH THE PROPELLERS PLACED OVER THE TAIL M.S. Thesis
GRAHAM SCOTT RHODES 1990 87 p
(Contract NCC1-123)
(NASA-CR-186900; NAS 1.26:186900) Avail: NTIS HC A05/MF A01 CSCL 01/3

An exploratory wind tunnel investigation was performed in the 30 x 60 foot wind tunnel to determine the low speed static stability and control characteristics into the deep stall regime of an advanced turboprop aircraft with the propellers located over the horizontal tail. By this arrangement, the horizontal tail could potentially provide acoustic shielding to reduce the high community noise caused by the propeller blades. The current configuration was a generic turboprop model equipped with 1 foot diameter single rotating eight bladed propellers that were designed for efficient cruise operation at a Mach number of 0.8. The data presented is static force data. The effects of power on the configuration characteristics were generally favorable. An arrangement with the propellers rotating with the outboard blades moving down was found to have significantly higher installed thrust than an arrangement with the propellers rotating with the inboard blades moving down. The primary unfavorable effect was a large pitch trim change which occurred with power, but the trim change could be minimized with a proper configuration design. Author

N90-26018# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
ROBUSTNESS EVALUATION OF H2 AND H(INFINITY) CONTROL THEORY AS APPLIED TO A TRANSPORT AIRCRAFT M.S. Thesis
RANDY L. ROBINSON Mar. 1990 119 p
(AD-A222795; AFIT/GAE/ENY/89D-30) Avail: NTIS HC A06/MF A01 CSCL 12/9

The purpose of this study was to evaluate the performance and stability robustness of a lateral autopilot designed for a transport aircraft using H2 and H(Infinity) control theory. The intent was to design a controller that met performance and robustness specifications over a range of flight conditions. First, a control structure to be used in designing the autopilot was developed. Once this was accomplished, it was formulated into the small gain problem. Controllers were then developed using H2 and H(Infinity) control theory. The final task involved evaluating the controllers developed in a closed loop simulation. GRA

09

RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A90-42698#
THE NORMAL SHOCK GENERATOR - AN INLET THROAT REGION RESEARCH APPARATUS FOR HIGH MACH APPLICATIONS
DALE C. BARR (Boeing Military Airplanes, Seattle, WA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 18 p. refs
(AIAA PAPER 90-1930) Copyright

This paper describes the design and operational characteristics of the Normal Shock Generator, a new test facility built by Boeing Military Airplanes for the investigation of normal shock behavior in mixed-compression inlet diffusers of supersonic and hypersonic aircraft. The device was equipped with an extensive array of pressure instrumentation, and with transparent sections which enabled high-speed videotape recordings of shadowgraph images to be obtained. Throat Mach numbers ranging from 1.5 to 2.8 were investigated. Bleed system operation was found to successfully improve boundary layer profile stability, and to delay shock-induced separation up to normal shock Mach numbers of 1.6. The effectiveness of a secondary injection system for artificial boundary layer thickening was established. Normal shock position control capabilities were determined for stationary, dynamic, and oscillating shock behavior. Under conditions of thick or separated boundary layers, it is demonstrated that diffuser wall static pressure distributions do not accurately indicate normal shock position. Author

A90-42791*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A TEST MATRIX SEQUENCER FOR RESEARCH TEST FACILITY AUTOMATION
TIMOTHY P. MCCARTNEY and EDWARD F. EMERY (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 8 p. Previously announced in STAR as N90-23416.
(AIAA PAPER 90-2386) Copyright

The hardware and software configuration of a Test Matrix Sequencer, a general purpose test matrix profiler that was developed for research test facility automation at the NASA Lewis Research Center, is described. The system provides set points to controllers and contact closures to data systems during the course of a test. The Test Matrix Sequencer consists of a microprocessor controlled system which is operated from a personal computer. The software program, which is the main element of the overall system is interactive and menu driven with pop-up windows and help screens. Analog and digital input/output channels can be controlled from a personal computer using the software program. The Test Matrix Sequencer provides more efficient use of aeronautics test facilities by automating repetitive tasks that were once done manually. Author

A90-44399*# Old Dominion Univ., Norfolk, VA.
RECENT AERODYNAMIC MEASUREMENTS WITH MAGNETIC SUSPENSION SYSTEMS
COLIN P. BRITCHER (Old Dominion University, Norfolk, VA) Oregon Conference on Low Temperature Physics, 7th, Eugene, OR, Oct. 23-25, 1989, Paper. 15 p. refs
(Contract NAG1-716)

This paper reviews recent aerodynamic tests of a family of slanted-base ogive-cylinders using the NASA Langley 13-inch Magnetic Suspension and Balance System. Results include drag, lift, pitching moment, support interference and base pressure measurements. Mach numbers were in the range 0.04 to 0.2.

Drag results are shown to be in satisfactory agreement with previous measurements. Significant support interferences were found at all test conditions. Comparison is made between interference free base pressures, obtained using remote telemetry, and sting cavity pressures. Test results and procedures are briefly discussed in the context of the proposed helium flow facility. Author

A90-44549
IMPROVED GUIDANCE AND CONTROL OF VEHICLES AND PERSONNEL ON THE GROUND WILL BENEFIT AIRPORT TRAFFIC CAPACITY
C. DEVASENAPATHY (International Civil Aviation Organization, Air Navigation Bureau, Montreal, Canada) ICAO Journal (ISSN 0018-8778), vol. 45, Jan. 1990, p. 14-16.
Copyright

Upgrading of specifications and guidance material related to surface movement guidance and control systems (SMGCS) is investigated. System adequacy is reviewed, noting that the design of SMGCS is principally affected by the visibility conditions in which operations are to be conducted and the density of traffic is to be handled. The ICAO Manual of Surface Movement Guidance and Control Systems explains how a system appropriate to the anticipated visibility conditions and traffic density can be designed. Aids and procedures that would merit special consideration when formulating proposals for improving airport capacity are outlined in detail. Issues include designation of standard routes for taxiing, selective operation of taxiway center-line lights, and production of airport and ground movement charts. Anticipated improvements are listed such as the introduction of rules for avoidance of collisions on aprons between aircraft and between aircraft and vehicles. L.K.S.

A90-45296
FINITE ELEMENT ANALYSIS OF THE TWELVE FOOT PRESSURIZED WIND TUNNEL
D. SABAHI (Norman Engineering Co., Los Angeles, CA) and T. L. ROSE (MacNeal-Schwendler Corp., Los Angeles, CA) IN: Computers in engineering 1989; Proceedings of the ASME International Computers in Engineering Conference and Exposition, Anaheim, CA, July 30-Aug. 3, 1989. Volume 2. New York, American Society of Mechanical Engineers, 1989, p. 389-397.
Copyright

Under contract to NASA, Norman Engineering has performed a complete redesign of the 12 Foot Pressurized Wind Tunnel. This effort was done to fulfill the requirements of the ASME Pressure Vessel code, which required analyses for loadings varying from full vacuum to being filled with approximately 55,000,000 pounds of water under pressure. This effort required the creation of several finite element models and utilization of advanced features in MSC/NASTRAN and CADAM, including superelements and global-local analysis. This paper summarizes the effort involved, with special attention to obstacles encountered and how they were overcome. Author

A90-45494* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CURRENT STATUS OF JOINT FAA/NASA RUNWAY FRICTION PROGRAM
THOMAS J. YAGER (NASA, Langley Research Center, Hampton, VA) and WILLIAM A. VOGLER (Planning Research Corp., McLean, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 7 p. refs
(SAE PAPER 892340) Copyright

Tests with specially instrumented NASA B-737 and FAA B-727 aircraft together with several different ground friction measuring devices have been conducted for a variety of runway surface types and wetness conditions. This effort is part of the Joint FAA/NASA Aircraft Ground Vehicle Runway Friction Program aimed at obaining a better understanding of aircraft ground handling performance under adverse weather conditions and defining relationships between aircraft and ground vehicle tire friction measurements. Aircraft braking performance on dry, wet, snow-, and ice-covered runway conditions is discussed together with ground vehicle friction data obtained under similar runway conditions. For the wet, compacted snow- and ice-covered runway conditions, the relationship between ground vehicles and aircraft friction data is identified. The influence of major test parameters on friction measurements such as speed, test tire characteristics, and surface contaminant type are discussed. The test results indicate that use of properly maintained and calibrated ground vehicles for monitoring runway friction conditions should be encouraged particularly under adverse weather conditions. The current status of the runway friction program is summarized and future test plans are identified. Author

A90-45503* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HELMET-MOUNTED DISPLAY SYSTEMS FOR FLIGHT SIMULATION
LOREN A. HAWORTH and NANCY M. BUCHER (NASA, Ames Research Center, Moffett Field, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 14 p. refs
(SAE PAPER 892352) Copyright

Simulation scientists are continually improving simulation technology with the goal of more closely replicating the physical environment of the real world. The presentation or display of visual information is one area in which recent technical improvements have been made that are fundamental to conducting simulated operations close to the terrain. Detailed and appropriate visual information is especially critical for nap-of-the-earth helicopter flight simulation where the pilot maintains an 'eyes-out' orientation to avoid obstructions and terrain. This paper describes visually coupled wide field of view helmet-mounted display (WFOVHMD) system technology as a viable visual presentation system for helicopter simulation. Tradeoffs associated with this mode of presentation as well as research and training applications are discussed. Author

A90-45504
DUAL SERVO OPTICAL PROJECTION SYSTEM (SOPS) - A SOLUTION FOR TWO CREWMEMBER AND NIGHT VISION GOGGLE DISPLAY NEEDS
JOE L. WALKER, JOSEPH BIEN, CHRIS CASTO, and BERNARD SMITH (McDonnell Douglas Helicopter Co., Mesa, AZ) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 7 p.
(SAE PAPER 892353) Copyright

A head-tracked projection display system has been developed which shows promise for both night vision goggle training and vehicles having two crewmembers. The display provides high resolution in the viewer's foveal region with lower resolution in the peripheral. Head tracking allows apparent high resolution everywhere within the servo's range of motion. The system has significant training value for Night Vision Goggles (NVG) which are typically head tracked displays. View separation of projected displays will permit independant scenes on a common dome screen. This gives crewmembers, in a close proximity environment, a correct perspective, wide field-of-view display. Author

A90-45505
IMPROVING COMPUTER TECHNIQUES FOR REAL-TIME DIGITAL FLIGHT SIMULATION
MICHAEL K. SINNETT, ROBERT B. OETTING, and BRUCE P. SELBERG (Missouri-Rolla, University, Rolla) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 6 p. Research supported by McDonnell Aircraft Co. refs
(SAE PAPER 892354) Copyright

Real-time digital flilght simulation is becoming increasingly more important in the aerospace industry. As the use of flight simulation for engineering development, research, and pilot training grows, so does the demand for engineers experienced in simulation technology. It is the role of the university to provide such trained individuals, but the cost of simulator systems can be prohibitive. The purpose of this paper is to present to the research and

educational community some considerations for reducing the cost requirements for simulator hardware, and for reducing the complexity and the computational load of the soft-ware model. Author

A90-45506
MANAGING MAN-IN-THE-LOOP SIMULATIONS
RICHARD E. COX and ANN M. SIZER (General Dynamics Corp., Fort Worth, TX) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 13 p.
(SAE PAPER 892355) Copyright

The outline of a process to accomplish a manned flight simulation experiment for research and engineering purposes, as opposed to flight simulation for training purposes, is presented. Simulation of managing man-in-the-loop projects is a complicated process necessitating a combination of technical skills, management techniques, and teamwork between a number of interested parties. The principal factors in this process are discussed and include planning and design, statement of requirements, and implementation and execution. Also discussed are software development management, engineering, and product evaluation. R.E.P.

A90-45507
REAL TIME DATA COLLECTION AND CONTROL IN A DISTRIBUTED SIMULATOR SYSTEM USING ETHERNET TCP/IP
DANIEL M. ALLEN and NAGABHUSHAN RAO (McDonnell Douglas Helicopter Co., Mesa, AZ) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 6 p.
(SAE PAPER 892356) Copyright

The purpose of this paper is to present the 'Stealth Protocol' which is a real time communication protocol residing above the TCP/IP layer. This protocol operates within a Local Area Network (LAN) in an ethernet communication environment. The McDonnell Douglas Helicopter Company (MDHC) simulation system consists of a distributed multi-processor VME chassis driving four simulators and several auxiliary stations. The system is controlled by one or more system control stations (SCS), acting as central control points which are themselves distributed. This protocol provides a mechanism for the central control points to maintain an 'open window' into the memory space of the real time system over ethernet and can access and modify memory, transparent to the real time applications. The 'Stealth Protocol' uses the socket connection techniques of the Ethernet-TCP/IP. Author

N90-25145# Carnegie-Mellon Univ., Pittsburgh, PA. Software Engineering Inst.
AN OBJECT-ORIENTED SOLUTION EXAMPLE: A FLIGHT SIMULATOR ELECTRICAL SYSTEM Final Report
KENNETH J. LEE and MICHAEL S. RISSMAN Feb. 1989 174 p
(Contract F19628-85-C-0003)
(AD-A219190; CMU/SEI-89-TR-5; ESD-TR-89-5) Avail: NTIS HC A08/MF A01 CSCL 14/2

An implementation of a subset of an aircraft flight simulator electrical system is described. It is a result of work on the Ada Simulator Validation Program (ASVP) carried out by members of the technical staff (MTS) at the Software Engineering Institute. The MTS developed a paradigm for describing and implementing flight simulator systems in general. The paradigm is a model for implementing systems of objects. The objects are described in a form of design specification called an object diagram. A full implementation of a system is described: Package specifications and bodies. The intent is to provide an example; the code is functional, but there is no assurance of robustness. Author

N90-25148 Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.
EVALUATION OF NONLINEAR MOTION-DRIVE ALGORITHMS FOR FLIGHT SIMULATORS Thesis
JEFF KIRDEIKIS Jun. 1989 251 p
(UTIAS-TN-272; ISSN-0082-5263) Copyright Avail: Issuing Activity

The effects on the performance of the nonlinear adaptive algorithm of changing the form of the cost function and allowing the gain, frequency, and damping parameters of the translational motion filters to adapt were determined. A general form of the quadratic cost function of degree N, where N = 2, 4, 6, and a piecewise-linear cost function were developed. A range scaling algorithm which accounts for the variations in the motion envelope with simulator position of the synergistic motion base was also developed. The evaluation of the algorithms employed idealized test signals, prerecorded aircraft maneuver inputs and a piloted simulation using a B747 aircraft model on the six degree-of-freedom UTIAS Flight Research Simulator. The results of the evaluation for the adaptive algorithm indicate that gain adaption produces the most realistic motion cues and is more effective at limiting motion base displacements than the frequency and damping of the combined gain, frequency and damping parameter adaption. Increasing the degree of the cost function decreased the sensitivity of the adaptive parameters. The fourth degree cost function with gain adaption was considered the best algorithm by the evaluation pilot. The performance of the range scaling algorithm was promising in many aspects but during the piloted simulation some oscillations on the rotational channels were sensed by the pilot. Author

N90-25149*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TRENDS: THE AERONAUTICAL POST-TEST DATABASE MANAGEMENT SYSTEM
W. S. BJORKMAN (Analytical Mechanics Associates, Inc., Mountain View, CA.) and M. J. BONDI Jan. 1990 130 p
(NASA-TM-101025; A-88225; NAS 1.15:101025) Avail: NTIS HC A07/MF A01 CSCL 14/2

TRENDS, an engineering-test database operating system developed by NASA to support rotorcraft flight tests, is described. Capabilities and characteristics of the system are presented, with examples of its use in recalling and analyzing rotorcraft flight-test data from a TRENDS database. The importance of system user-friendliness in gaining users' acceptance is stressed, as is the importance of integrating supporting narrative data with numerical data in engineering-test databases. Considerations relevant to the creation and maintenance of flight-test database are discussed and TRENDS' solutions to database management problems are described. Requirements, constraints, and other considerations which led to the system's configuration are discussed and some of the lessons learned during TRENDS' development are presented. Potential applications of TRENDS to a wide range of aeronautical and other engineering tests are identified. Author

N90-25150# Federal Aviation Administration, Atlantic City, NJ.
TAXIWAY SIGN EFFECTIVENESS UNDER REDUCED VISIBILITY CONDITIONS
PAUL H. JONES May 1990 23 p
(DOT/FAA/CT-TN90/20) Avail: NTIS HC A03/MF A01

An evaluation was conducted to determine whether any or all of the standard internally lighted taxiway guidance sign sizes, when located at the current recommended distance from the taxiway edge, provide adequate guidance in reduced visibility conditions. The L858R mandatory and L858Y informational types of taxiway guidance signs were used for the evaluation. The three standard sizes of each type of sign were set up at the maximum recommended distance from the taxiway edge. Tests were conducted at the intersection of taxiway B and runway 4-22 on the Atlanta City International Airport. Data were collected during periods of actual reduced visibility. Over 200 observations in visibilities between 400 to 1900 feet were collected. Typical low-speed taxi stopping distances were obtained through actual tests with a Boeing 727 aircraft. These stopping distance values were then compared to the actual recognition distances for the signs under low visibility conditions. From the data collected, all sizes of signs tested provided adequate guidance to allow a pilot

to recognize the sign message and take appropriate actions when needed. Author

N90-25153# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
LECTURE NOTES ON FLIGHT SIMULATION TECHNIQUES
M. BAARSPUL Aug. 1989 258 p
(LR-596; ETN-90-97165) Avail: NTIS HC A12/MF A02

The evolution of flight simulation techniques is reviewed and the main areas of flight simulator applications are addressed. The main components of a piloted flight simulator are described. Solutions to meet the high computer power required are elaborated. Available visual systems are described and characteristics of out-of-the-window visual simulation systems are discussed. Different types of motion systems (for example airline training and research) are described. The complete motion system, hardware and software, is discussed. Principles of mathematical modeling of aerodynamic, flight control, propulsion, landing gear and environmental characteristics are reviewed. An example of the identification of an aircraft mathematical model, based on flight and taxi tests, is presented. The application of ADA in realtime flight simulation is given. ESA

N90-26019*# MCAT Inst., Moffett Field, CA.
SUPERSONIC WIND TUNNEL NOZZLES: A SELECTED, ANNOTATED BIBLIOGRAPHY TO AID IN THE DEVELOPMENT OF QUIET WIND TUNNEL TECHNOLOGY Final Report
STEPHEN W. D. WOLF Washington Jul. 1990 82 p
(Contract NCC2-604)
(NASA-CR-4294; A-90163; NAS 1.26:4294) Avail: NTIS HC A05/MF A01 CSCL 14/2

This bibliography, with abstracts, consists of 298 citations arranged in chronological order. The citations were selected to be helpful to persons engaged in the design and development of quiet (low disturbance) nozzles for modern supersonic wind tunnels. Author, subject, and corporate source indexes are included to assist with the location of specific information. Author

N90-26020# Wright Research Development Center, Wright-Patterson AFB, OH.
WRIGHT RESEARCH AND DEVELOPMENT CENTER TEST FACILITIES HANDBOOK
MARGARET B. SKUJINS Jan. 1990 309 p
(AD-A222582; AD-E951478; WRDC-TR-90-0001) Avail: NTIS HC A14/MF A02 CSCL 14/2

This handbook contains a listing of Wright Research and Development Center facilities located at Wright-Patterson AFB OH. Facilities included are those of the Materials, Aero Propulsion and Power, Avionics, Flight Dynamics, and Electronic Technology laboratories and thehSignature Technology, Technology Exploitation, and Cockpit Integration directorates. Documented listings include information on facility type, capabilities, instrumentation, availability and POC. GRA

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A90-42705#
RECENT ADVANCES IN H2/O2 HIGH PRESSURE COAXIAL INJECTOR PERFORMANCE ANALYSIS
G. KRUELLE, W. MAYER, and C.-A. SCHLEY (DLR, Institut fuer chemische Antriebe und Verfahrenstechnik, Lampoldshausen, Federal Republic of Germany) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 15 p. refs
(AIAA PAPER 90-1959) Copyright

Advances in coaxial injector performance analysis performed at DLR are summarized. Work is based on the identification of relevant problem areas, and the attempt to arrive at global solutions by a mosaic kind of treatment. Greatest emphasis is given to the role of aerodynamic instabilities, whether radial or axial, of the fluid core interacting with the surrounding (fast) gas flow, with fluid and/or gas turbulence assumed as one of the exciting factors. Derived surface wave lengths of around 10 to the -6th m are consistent with literature but in some contrast to experimental evidence. The dependence of wavelengths/growth rates and (hypothetically) corresponding 'drop' formation on radial and axial velocity profiles is being studied analytically and numerically including biphasial phenomena to arrive at physically founded stripping rates, core shapes, and spray distributions. Drop histories required as an important input have been studied taking into account supercritical conditions. Experimental verification (cold test) has been started and is being extended using a high pressure facility providing gas/fluid density ratios and other characteristic parameters typical of high pressure H2/O2 injector performance. Author

A90-42776*# Santa Clara Univ., CA.
STREAMTUBE ANALYSIS OF SUPERSONIC COMBUSTION IN AN IN-TUBE-SCRAMJET
T. GARY YIP (Santa Clara University, CA), ANTHONY W. STRAWA (NASA, Ames Research Center, Moffett Field, CA), and GARY T. CHAPMAN (California, University, Berkeley) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 10 p.
(AIAA PAPER 90-2339) Copyright

The chemical nonequilibrium flow around a projectile propelled by supersonic combustion inside a tube of premixed, stoichiometric H2-air mixture is examined using a quasi-one-dimensional flow model and a 28-reactions/13 species chemistry model. Two series of calculations have been performed; one at the initial pressure 5 atm and the other 0.01 atm. Three projectile Mach numbers, namely 8, 10 and 5 were used. The minimum cone angle of the projectile forebody needed for triggering ignition can be estimated from the results of the calculations. The numerical results also show that high initial pressure reduces the induction and reaction zones to a single detonation front, and thrust is produced by the high pressure in the combustor and nozzle. Low initial pressure lengthens the reaction zone. In all the cases, the momentum of the flow changes only slightly because the tube in which the projectile travels limits the area for the nozzle flow to expand. Author

A90-42810#
FOREBODY DESIGN FOR THE AEROSPACEPLANE
L. H. TOWNEND, J. PIKE, T. R. F. NONWEILER, and E. ANN PARKER (APECS, Ltd., Liss, England) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 12 p. Research supported by McDonnell Douglas Corp. refs
(AIAA PAPER 90-2472) Copyright

The importance of low C(D0) to an accelerator vehicle leads to the need for low-drag forebodies which nonetheless avoid excessive length. Spatulate planfors may then result, with sharp unswept leading edges which intensify the high-speed heating problem. Passive and active means of cooling such bodies are studied, and some practicalities of spatulates assessed. Author

A90-43460
THE 21ST CENTURY IN SPACE; PROCEEDINGS OF THE THIRTY-FIFTH ANNUAL AAS CONFERENCE, SAINT LOUIS, MO, OCT. 24-26, 1988
GEORGE V. BUTLER, ED. (McDonnell Douglas Astronautics Co., Huntington Beach, CA) Conference supported by McDonnell Douglas Corp. San Diego, CA, Univelt, Inc., 1990, 445 p. For

individual items see A90-43461 to A90-43485.
Copyright

Attention is given to such topics as the Space Station in the 21st century, large space structures, space utilization and applications, automation/robotics, and aerodynamics for manned Mars missions and hypervelocity flight. Consideration is also given to tracking/data, space sciences, life sciences, structures/materials, and rocket propulsion. B.J.

A90-44735#
OFF-DESIGN PERFORMANCE OF HYPERSONIC WAVERIDERS
LYLE N. LONG (Pennsylvania State University, University Park) Journal of Aircraft (ISSN 0021-8669), vol. 27, July 1990, p. 639-646. Research supported by the Lockheed Aeronautical Systems Co. Previously announced in STAR as N88-13244. refs
(Contract F33615-84-C-3005)
Copyright

Waveriders are being considered more and more as potential aerospace vehicles. However there are several questions regarding these configurations that must be answered before they can be considered viable designs. The most significant problems are related to aerothermal heating, propulsion integration, and off-design performance. Off-design performance predictions for two generic waveriders are presented. The results are from a numerical method based upon the nonlinear, inviscid Euler equations. Comparisons to experimental data are also shown. Author

A90-44752
SST/HST AIR TRAFFIC - CHALLENGE FOR THE FUTURE [SST/HST-FLUGVERKEHR - HERAUSFORDERUNG AN DIE ZUKUNFT]
BORIS LASCHKA and PH. POISSON-QUINTON Luft- und Raumfahrt (ISSN 0173-6264), vol. 11, 2nd Quarter, 1990, p. 38-42. In German.
Copyright

The future market for supersonic aircraft is discussed. Environmental problems caused by such aircraft, especially noise and pollution, are examined, and solutions are suggested. The future of the hypersonic transport is briefly addressed. C.D.

A90-45135#
THE ASCENDING TRAJECTORIES PERFORMANCE AND CONTROL TO MINIMIZE THE HEAT LOAD FOR THE TRANSATMOSPHERIC AERO-SPACE PLANES
J. BARLOW (Maryland, University, College Park) and A. AL-GARNI IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1-11. refs
(AIAA PAPER 90-2828) Copyright

The goal of airbreathing transatmospheric vehicle (TAV) ascending trajectory performance and control definition is the minimization of heat loads/unit area near the stagnation point, modeling the vehicle as a point-variable mass with drag polar and variable thrust. Initially, the present effort proceeds analytically to define the aerodynamic and thrust controls required for TAV transfer from one specified state to another, while satisfying such equality constraints as constant dynamic pressure and constant rate-of-climb. Extensive numerical optimization algorithms are then applied. An illustrative numerical example is presented. O.C.

A90-45137*# Michigan Univ., Ann Arbor.
OPTIMAL PLANE CHANGE BY LOW AERODYNAMIC FORCES
NGUYEN X. VINH (Michigan, University, Ann Arbor) and DER-MING MA (Chung Shan Institute of Science and Technology, Lungtan, Republic of China) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 24-31. refs
(Contract JPL-956416)
(AIAA PAPER 90-2831) Copyright

This paper presents the exact dimensionless equations of motion and the necessary conditions for the computation of the optimal trajectories of a hypervelocity vehicle flying through a nonrotating spherical planetary atmosphere. It is shown that there are two types of maneuvers with nearly identical plane change. In the hard maneuver, the vehicle is pulled down to low altitude for aerodyamic plane change before exit at the prescribed final speed. In the slow maneuver which is described in detail in this paper, the vehicle remains in orbital flight with a small incremental plane change during each passage through the perigee. This maneuver requires several revolutions, and the technique for computation is similar to that in the problem of contraction of orbit. Author

A90-45149*# Princeton Univ., NJ.
THRUST LAW EFFECTS ON THE LONGITUDINAL STABILITY OF HYPERSONIC CRUISE
NIKOS MARKOPOULOS and KENNETH D. MEASE (Princeton University, NJ) IN: AIAA Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. *Washington, DC, American Institute of Aeronautics and* Astronautics, 1990, p. 141-155. refs
(Contract NAG1-907)
(AIAA PAPER 90-2820) Copyright

In the present analytical treatment of the cruising flight stability of an aerospacecraft in nearly circular orbit, on the basis of a thrust law which arbitrarily depends on altitude, speed, and angle of attack, attention is given to thrust law effects on the translational (height and phugoid) and rotational (angle of attack) modes. The partial derivatives of the propulsive forces in conjunction with the aerodynamic forces, with respect to speed and altitude, are noted to exert a major influence on the stability of translational dynamics; the partial derivative of the component of propulsive and aerodynamic forces which is perpendicular to vehicle velocity (with respect to the angle of attack) is a primary determinant of the damping of angle-of-attack oscillations, while the partial derivative of the sum about the center of mass of aerodynamic and propulsive pitching moments, with respect to the angle of attack, determines the corresponding period. O.C.

N90-25189# Deutsche Gesellschaft fuer Luft- und Raumfahrt, Bonn (Germany, F.R.).
THE JET ENGINE: 1932 [DER STRAHLMOTOR: 1932]
JOHANNES WINKLER 1989 180 p In GERMAN
(ISBN-3-922010-49-0; ETN-90-96784) Avail: NTIS HC A09/MF A01

A first publication of a 1932 manuscript about motors is presented. Several topics are addressed: thermodynamics of booster motors, Ziolkouski equations, space vehicles, flight stability, aerodynamic braking, space stations and intercontinental rockets. For mean powers, solid fuels were advisable. In the case of liquid fuels, methane and hydrogen are recommended because of their high potential energy. ESA

N90-26055*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
BACKGROUND, CURRENT STATUS, AND PROGNOSIS OF THE ONGOING SLUSH HYDROGEN TECHNOLOGY DEVELOPMENT PROGRAM FOR THE NASP
R. L. DEWITT, T. L. HARDY, M. V. WHALEN, G. P. RICHTER, and T. M. TOMSIK 1990 16 p Presented at the 8th World Hydrogen Energy Conference, Honolulu, HI, 22-27 Jul. 1990; sponsored by Hawaii Natural Energy Inst.
(NASA-TM-103220; E-5634; NAS 1.15:103220) Avail: NTIS HC A03/MF A01 CSCL 22/2

Among the Hydrogen Projects at the NASA Lewis Research Center (NASA LeRC), is the task of implementing and managing the Slush Hydrogen (SLH2) Technology Program for the United States' National AeroSpace Plane Joint Program Office (NASP JPO). The objectives of this NASA LeRC program are to provide verified numerical models of fluid production, storage, transfer, and feed systems and to provide verified design criteria for other engineered aspects of SLH2 systems germane to a NASP. The pursuit of these objectives is multidimensional, covers a range of problem areas, works these to different levels of depth, and takes advantage of the resources available in private industry, academia,

and the U.S. Government. A summary of the NASA LeRC overall SLH2 program plan, is presented along with its implementation, the present level of effort in each of the program areas, some of the results already in hand, and the prognosis for the effort in the immediate future. Author

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A90-42675#
MARITIME ENVIRONMENT AIRFRAME MATERIAL FATIGUE TESTING
M. OORE (IMP Group, Ltd., Aerospace Div., Halifax, Canada) and L. T. RUSSELL (Nova Scotia, Technical University, Halifax, Canada) IN: Annual General Meeting of the Canadian Aeronautics and Space Institute, 36th, Ottawa, Canada, May 15, 16, 1989, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1989, p. 46-1 to 46-21. Research supported by CRAD. refs

The objective was to initiate a program for generating the airframe material fatigue data base required for engineering support of the Canadian Air Force fleet operating in the Atlantic region. This study has identified representative environmental conditions and defined a corrosion and fatigue testing procedure. It was followed by testing specimens of 2024-T3 clad aluminum sheet each containing a drilled central hole. The specimens were subjected to varying durations of preexposure to salt spray under controlled laboratory conditions and then fatigue-tested with constant amplitude cyclic loading. The data gathered were used to generate fatigue S-N curves. The effect of corrosion preexposure time on fatigue life is presented. Author

A90-42725#
SOLID FUEL IGNITION AND COMBUSTION CHARACTERISTICS UNDER HIGH-SPEED CROSSFLOWS
K. K. KUO (Pennsylvania State University, University Park), T. S. SNYDER, T. A. JARYMOWYCZ, and K. K. PACE AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 9 p. refs
(Contract N00014-86-K-0468)
(AIAA PAPER 90-2075) Copyright

The ignition and combustion characteristics of HTPB solid fuels with various percentages of boron loadings have been studied under high-speed, high-enthalpy crossflows. A blowdown wind tunnel was utilized to simulate a SFRJ combustor with pressures from 0.26 to 0.55 MPa and temperatures from 620 to 1040 K. Regression rates of the solid fuels were determined as a function of boron percentage and freestream temperature and pressure using a real-time X-ray radiography system . The addition of 10 percent boron to HTPB enhanced the ignition characteristics of the sample and resulted in the fastest regression rate. Samples loaded with high percentages of boron had lower regression rates. This decrease is caused by the heat sink effect of a large number of boron particles, the shielding of heat feedback from the diffusion flame to the sample surface, and the decreased gas-phase reactions by the reduction in HTPB percentage. Author

A90-42769#
APPLICATION OF ADVANCED MATERIALS TO AIRCRAFT GAS TURBINE ENGINES
A. M. JOHNSON and P. K. WRIGHT (GE Aircraft Engines, Cincinnati, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 11 p. refs
(AIAA PAPER 90-2281) Copyright

Critical issues regarding the application of advanced materials to aircraft gas turbine engines are discussed. The applications of conventional and advanced materials to such engines are compared. Fundamental issues involving material composition and processing, secondary processes, material manufacturing base, design and life prediction capabilities, suitable NDE methods, and cost are considered. C.D.

A90-43204
ALUMINUM SURFACE PREPARATION FOR AIRCRAFT FIELD REPAIR
WARREN D. STEINMETZ and WILLIAM J. TRZASKOS (American Cyanamid Co., Havre de Grace, MD) SAMPE Quarterly (ISSN 0036-0821), vol. 21, July 1990, p. 34-39.
Copyright

In any aircraft field repair process involving adhesive bonding, proper surface preparation of metal details is crucial to long term bond durability. This paper addresses the relative effectiveness of various metal surface preparations and primer combinations. Emphasis is placed on long term durability under hostile environments. A variety of metal to metal test configurations are examined. Recommendations for the most durable type of surface preparation and primer combination is given. Author

A90-43670
COMBUSTION OF PMMA, PE, AND PS IN A RAMJET
C. W. M. VAN DER GELD (Eindhoven, Technische Universiteit, Netherlands), P. A. O. G. KORTING (TNO, Prins Maurits Laboratoria TNO, Rijswijk, Netherlands), and T. WIJCHERS (Delft, Technische Universiteit, Netherlands) Combustion and Flame (ISSN 0010-2180), vol. 79, March 1990, p. 299-306. refs
Copyright

The combustion behavior of polymethylmethacrylate (PMMA), polyethylene (PE), and polystyrene (PS) with air was investigated in a connected pipe test facility; spectroscopy showed the presence of OH, C2, and CH and temperatures between 1300 and 3000 K during combustion. Particular attention was focused on regression rate and combustion efficiency and the role of temperature and soot production. The present investigation gives an understanding of the most important phenomena that control (or emanate from) the combustion of a cylindrical solid fuel with a rearward facing step, and this has application for solid fuel ramjets, the safe burning of toxic waste, and hot gas generators. Author

A90-43855
A COMPARISON OF HONEYCOMB-CORE AND FOAM-CORE CARBON-FIBRE/EPOXY SANDWICH PANELS
M. AKAY (Ulster, University, Jordanstown, Northern Ireland) and R. HANNA (Short Brothers, PLC, Belfast, Northern Ireland) Composites (ISSN 0010-4361), vol. 21, July 1990, p. 325-331. refs
Copyright

Cellular core sandwich panels of carbon-fiber/epoxy fabric laminate skins, simulating the construction of an aircraft flap, were cured and bonded in a single-step autoclave operation. Nomex honeycomb and Rohacell WF foam of different densities were employed as the core material. The panels were examined to identify voids in the laminate skins and cell collapse and coalescence in the foam core. Test-pieces were subjected to low-energy impact and the induced damage was determined by ultrasonic C-scan. The maximum damage area in the face-skin was comparable to the projectile cross-sectional area. Residual compressive capacity showed an asymptotic decrease with increasing impact levels, most panels gave similar values but the modes of failure were different depending on the type of core. The resistance of the separate panel components to full impact puncture was assessed using instrumented impact load-deflection traces. Author

A90-44173
A FRIENDLY ALLOY
C. H. SYMONDS (Inco Alloys International, Ltd., Hereford, England) Aerospace Composites and Materials (ISSN 0954-5832), vol. 2, July-Aug. 1990, p. 39, 40, 42.
Copyright

The contributions of metallurgy to jet aircraft technology are discussed. Mechanical alloying and inert gas atomization with HIP are examined as powder processes for alloy creation. The use of powder atomization and HIP to produce the rotating parts of gas turbine engines is addressed. C.D.

A90-44175
LOSE WEIGHT WITH AL-LI
GEORGE MARSH Aerospace Composites and Materials (ISSN 0954-5832), vol. 2, July-Aug. 1990, p. 46-48.
Copyright
Advances in the acceptance of Al-Li for use in aircraft structures are reviewed. The rolling and fabrication of the material are described, and the resultant material properties are discussed. The evolution of size capability for Al-Li at two plants is shown. C.D.

A90-44348
QUENCH SENSITIVITY OF AIRFRAME ALUMINIUM ALLOYS
H. J. KOLKMAN, W. G. J. 'T HART, and L. SCHRA (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Strength of metals and alloys (ICSMA 8); Proceedings of the Eighth International Conference, Tampere, Finland, Aug. 22-26, 1988. Volume 2. Oxford, England and Elmsford, NY, Pergamon Press, 1989, p. 597-602.
Copyright
TEM investigations were conducted on the quench sensitivity of six precipitation-hardened aluminum alloys for aerospace applications. The Vickers hardness and electrical conductivity were obtained as functions of the distance from the quench plane and of the initial quench rate. The results show that the alloys have different precipitate and dispersoid types, which are given. The quench sensitivity is found to be mainly due to solute depletion associated with heterogeneous precipitation at dispersoids for low quench rates. C.D.

A90-44816
SLIP-CAST HOT ISOSTATICALLY PRESSED SILICON NITRIDE GAS TURBINE COMPONENTS
R. DILLINGER, J. HEINRICH, and J. HUBER (Hoechst Ceram Tec AG, Selb, Federal Republic of Germany) IN: Ceramic materials research; Proceedings of the Symposium of the 1988 E-MRS Spring Conference, Strasbourg, France, May 31-June 2, 1988. Amsterdam and New York, Elsevier Science Publishers, 1989, p. 373-378. Research supported by BMFT. refs
Copyright
This work considers the production of gas turbine components from hot isostatically pressed reaction-bonded silicon nitride (RBSN) by aqueous slip casting of silicon metal powder followed by nitridation and postdensification of the components by hot isostatic pressing. For subsequent densification of the RBSN components, the slip also must contain powders of the sintering aids yttria and alumina. In a first step the phase system silicon-water was investigated: the dependence of the rate of hydrolysis, the viscosity, and the surface charge of the suspended powder particles on the pH were determined. Comparable investigations were done with the phase system silicon-water-sintering aids. Various deflocculants with different pH values were tested. Test specimens and parts for the gas turbine were cast into plaster molds, nitrided, and hot isostatically pressed. Author

A90-45028
A STUDY OF THE ELECTROPHYSICAL PHENOMENA IN THE COMBUSTION CHAMBERS OF JET ENGINES [ISSLEDOVANIIA ELEKTROFIZICHESKIKH IAVLENII V KAMERAKH SGORANIIA REAKTIVNYKH DVIGATELEI]
S. N. CHEREPNIN Fizika Goreniia i Vzryva (ISSN 0430-6228), vol. 26, Mar.-Apr. 1990, p. 58, 59. In Russian.
Copyright
The electrophysical characteristics of the combustion process in the combustion chambers of jet engines were studied experimentally using an experimental 100-mm-diameter metal combustion chamber operating on a propane-butane fuel. The electrical potential was measured by a passive probe (without the application of an external emf) consisting of 0.1-mm-diameter nichrome wire enclosed in a ceramic tube. It is found that the electrical potential changes with the fuel/oxidizer ratio and fuel combustion heat in the same way as in open flame. V.L.

A90-45487
CONSIDERATIONS IN USING BROAD SPECIFICATION FUELS FOR AIRCRAFT PROPULSION
J. D. COHEN (GE Aircraft Engines, Cincinnati, OH) and SUSAN J. VINING (U.S. Navy, Naval Air Propulsion Test Center, Trenton, NJ) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 10 p. refs
(SAE PAPER 892330) Copyright
Enhancement of aviation fuel supplies at some future date may become necessary due to changing geopolitical conditions or reduced petroleum availability. Use of non-standard fuels may become a necessity on either an emergency or permanent basis. Two engine programs, conducted jointly by the U.S. Navy and GE Aircraft Engines, investigated the effects incurred by using broad specification fuels. Engine component and full-scale engine tests were conducted on the F404-GE-400 turbofan and the T700-GE-701 turboshaft engines. Results have demonstrated that these engines can operate successfully on various alternative fuels. However, there are penalties to engine performance, operability, and durability. Author

A90-45488
MODELLING OF FUEL EFFECTS ON NAVAL AIRCRAFT OPERATIONS
SUSAN J. VINING (U.S. Navy, Naval Air Propulsion Test Center, Trenton, NJ) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 13 p. refs
(Contract N00140-86-C-9070; N00140-86-C-9069)
(SAE PAPER 892331) Copyright
A computer model has been developed which can predict effects of broad specification fuels in place of the standard JP-5 on the performance, operability, and life cycle cost of U.S. Navy aircraft systems. The software has been applied to four Naval systems: the F-14A/TF30, the F/A-18/F404, the SH-60B/T700, and the S-3A/TF34. The model, based on fuel property effect correlations developed from alternative fuel engine component and full-scale engine tests, requires fuel property input data from the user. Comparisons are then made of aircraft operation with the alternative fuel versus a baseline JP-5. Author

A90-45490
IMPROVED STEEL FOR LANDING GEAR DESIGN
WILLIAM W. MACY, MARK A. SHEA, RIGOBERTO PEREZ, and ROBERT E. NEWCOMER (McDonnell Aircraft Co., Saint Louis, MO) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 6 p.
(SAE PAPER 892335) Copyright
An improved high-strength, high-toughness steel has been developed which shows considerable promise for landing gear applications. Previous materials provided high strength or high toughness, but not both. The improved material is a modified chemistry of AF1410 steel with increased carbon and an altered heat treat process. Tensile ultimate strengths (Ftu) of over 1.79 GPa have been achieved while maintaining plane-strain fracture toughness in excess of 110 MPa/sq rt m. In addition, the material has low sensitivity to environmental factors such as hydrogen embrittlement and stress corrosion cracking. Author

A90-45708#
AN INVESTIGATION ON BORON USED AS A COMPONENT OF SOLID PROPELLANT
LINGQIAN ZANG Journal of Propulsion Technology (ISSN 1001-4055), Aug. 1990, p. 56-62. In Chinese, with abstract in English. refs
In this paper the worldwide investigation of boron as a component of propellant is described. It is pointed out that to use boron as a main component of propellant, problems such as the

consistency of commercial boron powder with adhesive of propellant, the composition technology of propellant, the combustion efficiency of boron and so on should be solved. To improve the combustion efficiency up to a practically acceptable level, not only propellant composition but also, more importantly, proper organization of combustion in engines and optimization of combustion parameters are needed. Author

N90-25090# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Unternehmensgruppe Transport- und Verkehrsflugzeuge.
INVESTIGATION ON SHEET MATERIAL OF 8090 AND 2091 ALUMINIUM-LITHIUM ALLOY
WALTER ZINK, JUERGEN WEILKE, LUEDER SCHWARMANN, and KARL HEINZ RENDIGS *In its* Research and Development: Technical and Scientific Publications 1989 p 123-132 1989 Presented at AGARD Conference, Mierlo, Netherlands, 2-7 Oct. 1988
(MBB-UT-122/89-PUB) Avail: NTIS HC A15/MF A02

Test results are presented for semi-finished sheet material products compared with alloy 2024 T3 as reference material. The new aluminum-lithium alloys offer considerable weight gain potential without extensive conversions of their manufacturing facilities. Tensile and fatigue tests were carried out. Compression and bearing strength, fatigue on lap joints, crack growth behavior, fracture toughness and intergranular corrosion were particularly studied. It is concluded that 8090 C alloy must be incorporated in the major fatigue test specimen of the Airbus 330 and 340. ESA

N90-25091# Messerschmitt-Boelkow-Blohm G.m.b.H., Hamburg (Germany, F.R.). Unternehmensgruppe Transport- und Verkehrsflugzeuge.
DAMAGE TOLERANCE DEMONSTRATION FOR A310-300 CFPR COMPONENTS
OGUZ GOEKGOEL *In its* Research and Development: Technical and Scientific Publications 1989 p 133-140 1989 Presented at ICAF Symposium, Jerusalem, Israel, 1989
(MBB-UT-012/89-PUB) Avail: NTIS HC A15/MF A02

The treatment of damages concerning allowable sizes and quality assurance in production of CERP (Carbon Fiber Reinforced Plastics) fin box is presented. Severe failure cases were investigated by finite element method analysis, such as rudder attachment lugs or attachment lugs to fuselage failing. Tests were carried out for validation of static strength, fatigue and damage tolerance. Environmental tests with aggressive fluids were performed on composite structures and showed a very small sensitivity to products used on aircraft servicing. Critical damages were calculated for all CFRP fin areas, by using degradation values from panel tests and the safety factors from the finite element method calculations. A schedule of necessary repairs for each type of damage was established. ESA

N90-25222# Federal Aviation Administration, Atlantic City, NJ.
FLAMMABILITY OF FIRE RESISTANT, AIRCRAFT HYDRAULIC FLUID
DAVID BLAKE Apr. 1990 17 p
(DOT/FAA/CT-TN90/19) Avail: NTIS HC A03/MF A01

This study was undertaken following a wheel-well fire in a 737 aircraft. Hydraulic fluid appeared to be the fuel for this fire. Twenty-six tests were conducted with Monsanto Skydrol 500B-4 and Chevron Hy-Jet IV-A fire resistant phosphate ester-based hydraulic fluid. The testing was conducted to determine the conditions necessary for ignition and self-sustained burning of these fluids and to attempt to simulate what probably happened in the wheel-well fire. The testing determined that under certain conditions these fluids will ignite and continue to burn after the ignition source is removed. Author

N90-25226# National Aeronautical Establishment, Ottawa (Ontario). Structures and Materials Lab.
PROCESSING OF ADVANCED CERAMICS WHICH HAVE POTENTIAL FOR USE IN GAS TURBINE AERO ENGINES
T. M. MACCAGNO Feb. 1989 5 p
(AD-A220988; NAE-AN-58; NRC-30057) Avail: NTIS HC A01/MF A01 CSCL 11/3

Si3N4 and SiC based advanced ceramics that were produced by hot isostatic pressing (HIPing) have a good potential to be used as hot section components in gas turbine aero engines. Background is provided for an NAE-SML investigation of this potential. A general overview of the many fabrication methods that were used to produce both monolithic ceramics and SiC whisker reinforced composite ceramics is presented. This is followed by a comprehensive survey of past efforts to produce Si3N4 and SiC based ceramics by HIPing. It is apparent that many of these efforts have involved HIPing of material that was already densified by sintering, but such an approach does not really allow the full benefits of HIP processing to be realized. On the other hand, HIPing of Si3N4 based composite produced by reaction bonding may result in ceramic material of superior quality. Author

N90-25228# Wright Research Development Center, Wright-Patterson AFB, OH. Fuels Branch.
MICRO SEPAROMETER AND BALL-ON-CYLINDER LUBRICITY EVALUATOR TESTS OR CORROSION INHIBITOR/LUBRICITY IMPROVER ADDITIVES Final Report, 19 Jul. 1988 - 31 May 1989
PATRICIA D. LIBERIO Sep. 1989 29 p
(Contract AF PROJ. 3048)
(AD-A221339; WRDC-TR-89-2098) Avail: NTIS HC A03/MF A01 CSCL 21/4

Due to the addition of the Ball-On-Cylinder Lubricity Evaluator (BOCLE) and Test for Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer to the Military Specification MIL-I-25017, Revision E, all of the Corrosion Inhibitor/Lubricity Improver additives on the Qualified Products List, QPL-25017-15, had to be tested using these methods. During this program each additive was evaluated and the results are given The BOCLE testing resulted in two inhibitors being disqualified from the QPL. The Minimum Effective Concentration (MEC) of eight inhibitors shall be increased in the next revision of QPL-25017. Due to the Micro Separometer (MSEP) testing, two inhibitors shall have new Maximum Allowable Concentration (MAC) and one inhibitor shall be removed from the new QPL. GRA

N90-25236# Allied-Signal Corp., Des Plaines, IL. Engineered Materials Research Center.
ADVANCED FUEL PROPERTIES, PHASE 1 Interim Report, Oct. 1987 - May 1989
K. R. SQUIRE, C. L. VORRES, J. T. DONNER, J. W. SOUZA, and M. G. KOEHLER Dec. 1989 135 p Prepared in cooperation with UOP Research Center, 50 East Algonquin Road, Des Plaines, IL
(Contract F33615-87-C-2709)
(AD-A219788; WRDC-TR-89-2119) Avail: NTIS HC A07/MF A01 CSCL 21/4

To develop fuels needed for the high performance aircraft of the future, the ability to design fuels based on the satisfaction of a set of properties is needed. A project to develop software to accomplish this goal was developed. The ability to determine numerous physical and thermochemical properties of pure-component organic fuel candidates based solely on molecular structure(s) of the molecules of interest is examined. The result of Phase 1 is the software that obtains various physical and thermochemical properties for liquids, ideal gases, and real gases at various temperatures and pressures. Because of the number of methods that were found for predicting properties of molecules, a priority scheme was developed which utilizes the best method to predict the desired property. Additionally, the system has designed within it the ability to interface with an expert system to allow the system to better decide what method(s) should be used to predict each desired property. GRA

N90-26080*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CARBON-CARBON COMPOSITES: EMERGING MATERIALS FOR HYPERSONIC FLIGHT
HOWARD G. MAAHS 1989 18 p Submitted for publication
(NASA-TM-103472; NAS 1.15:103472) Avail: NTIS HC A03/MF A01 CSCL 11/4

An emerging class of high temperature materials called carbon-carbon composites are being developed to help make advanced aerospace flight become a reality. Because of the high temperature strength and low density of carbon-carbon composites, aerospace engineers would like to use these materials in even more advanced applications. One application of considerable interest is as the structure of the aerospace vehicle itself rather than simply as a protective heat shield as on Space Shuttle. But suitable forms of these materials have yet to be developed. If this development can be successfully accomplished, advanced aerospace vehicles such as the National Aero-Space Plane (NASP) and other hypersonic vehicles will be closer to becoming a reality. A brief definition is given of C-C composites. Fabrication problems and oxidation protection concepts are examined. Applications of C-C composites in the Space Shuttle and in advanced hypersonic vehicles as well as other applications are briefly discussed. Author

N90-26087# Rolls-Royce Ltd., Derby (England). Manufacturing Technology.
METAL MATRIX COMPOSITES AND POWDER PROCESSING FOR AERO-ENGINE APPLICATIONS
D. DRIVER 3 Jul. 1989 26 p Presented at the BNF 7th International Conference on the Materials Revolution through the 90's, Oxford, England, 3-5 Jul. 1989
(PNR90617; ETN-90-97135) Copyright Avail: NTIS HC A03/MF A01

Engineering opportunities and processing implications for composites offering potential in aeroengines are addressed, with particular emphasis on metal matrix composites. Compressor disc and blade applications, and fiber and matrix characteristics are discussed. High temperature metal matrix composites and powder processing are considered. The exploitation of metal matrix composites offers particular advantages for stiffness-critical applications while powder processing provides the potential for near net shape components which, when coupled with microstructural control, gives extended component lives. ESA

N90-26094*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPERSONIC REACTING INTERNAL FLOW FIELDS
J. PHILIP DRUMMOND 1989 82 p Submitted for publication
(NASA-TM-103480; NAS 1.15:103480) Avail: NTIS HC A05/MF A01 CSCL 21/2

The national program to develop a trans-atmospheric vehicle has kindled a renewed interest in the modeling of supersonic reacting flows. A supersonic combustion ramjet, or scramjet, has been proposed to provide the propulsion system for this vehicle. The development of computational techniques for modeling supersonic reacting flow fields, and the application of these techniques to an increasingly difficult set of combustion problems are studied. Since the scramjet problem has been largely responsible for motivating this computational work, a brief history is given of hypersonic vehicles and their propulsion systems. A discussion is also given of some early modeling efforts applied to high speed reacting flows. Current activities to develop accurate and efficient algorithms and improved physical models for modeling supersonic combustion is then discussed. Some new problems where computer codes based on these algorithms and models are being applied are described. Author

N90-26104# California Univ., Berkeley. Dept. of Mechanical Engineering.
LIQUID FUELED RAMJET COMBUSTION INSTABILITY: ACOUSTICAL AND VORTICAL INTERACTIONS WITH BURNING SPRAYS Final Technical Report, 5 May 1985 - 30 Apr. 1988
W. A. SIRIGNANO, R. BHATIA, and K. MOLAVI 15 May 1990 99 p
(Contract N00014-85-K-0658)
(AD-A222752) Avail: NTIS HC A05/MF A01 CSCL 21/4

A theoretical/computational study of liquid-fueled ramjet instability has been performed. The roles of droplet vaporization and spray combustion processes have been determined as rate-controlling factors on the performance and stability of combustors. The effects of vaporization, mixing, turbulent transport, and chemical kinetics were evaluated. The impact of variations in geometry, initial droplet size, equivalence ratio, and various numerical factors were determined. The study had four major components: individual droplet studies, a one-dimensional combustor analysis, a planar combustor study, and an axisymmetric study. A predictive capability was developed. Vaporization processes and droplet trajectories were found to affect performance and stability significantly. GRA

N90-26106# Aeronautical Research Labs., Melbourne (Australia). Dept. of Defence.
STATISTICAL TREATMENT OF SLOW STRAIN RATE DATA FOR ASSESSMENT OF HYDROGEN EMBRITTLEMENT IN LOW ALLOY HIGH STRENGTH STEEL
W. J. POLLOCK Apr. 1990 30 p
(ARL-MAT-R-122; AR-006-084; AD-A222732) Copyright Avail: NTIS HC A03/MF A01

Slow strain rate testing was used to quantify the degree of hydrogen embrittlement produced in high strength 4340 steel by plating processes and aircraft maintenance chemicals. The results of slow strain rate tests, conducted at a crosshead displacement rate of 2 x 10(exp-4)mm/s using samples of three notched tension specimens in various paint strippers, show that a mean fracture stress of 1850 MPa can be correlated with the pass/fail criterion for acceptability of paint strippers in an existing Standard Notched C-ring Test. Statistical analysis of the slow strain rate data allows criteria to be established which will ensure a 99 percent probability of identifying all paint strippers that fail the Notched C-ring Test. This analysis is also used to trade a series of products and processes in terms of their tendency to cause hydrogen embrittlement, and to identify environmental parameters that cause excessive scatter in hydrogen embrittlement tests. Criteria are also specified for acceptability of each heat treatment batch of 4340 steel specimens to ensure reproducibility of results obtained from slow strain rate tests. Author

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ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A90-42667#
NEXT-GENERATION AUTOMATIC TEST EQUIPMENT FOR MILITARY SUPPORT
M. WASSERMAN (Canadian Marconi Co., Montreal, Canada) IN: Annual General Meeting of the Canadian Aeronautics and Space Institute, 36th, Ottawa, Canada, May 15, 16, 1989, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1989, p. 31-1 to 31-11. refs

The underlying philosophy and design of automatic testing

equipment (ATE) for military systems have undergone modification in view of the increasingly important requirement of forward deployment. ATE stations must accordingly become smaller and lighter for the sake of transportability, as well as hardier and easily reconfigurable. Ease of operation and maintenance also become critical. Among the technologies identified as essential for the implementation of these stringent ATE design requirements are the IEE-488, MIL-STD-1553, VME, VXI, and SCSI data buses, 'instruments on a card' technology, optical disk drives, touch-screen technology, and expert system-related software. O.C.

A90-42685#
NUMERICAL SIMULATION OF NONPREMIXED TURBULENT FLOW IN A DUMP COMBUSTOR
D. LENTINI (Roma I, Universita, Rome, Italy) and W. P. JONES (Imperial College of Science, Technology, and Medicine, London, England) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 9 p. refs
(AIAA PAPER 90-1858) Copyright

A computational model for the prediction of a turbulent, reacting, recirculating flowfield in the combustion chamber of a subsonic combustion ramjet is presented. It is based on the k-epsilon turbulence model's conserved scalar approach, with a convenient assumption for its probability density function which is intended to reduce the computing time, and on the SIMPLE solver. It is validated by comparison with experimental data on the mean values of velocity and temperature in a hydrogen-fed dump combustor. The merits and deficiencies of this approach are examined and the possible reasons for disagreement are discussed. Author

A90-42739#
COMPUTATIONAL INVESTIGATION OF TWO-DIMENSIONAL EJECTOR NOZZLE FLOW FIELDS
J. DONALD MCFARLAN, CARL B. MCMURRY, and W. FRANK SCAGGS (General Dynamics Corp., Fort Worth, TX) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 14 p. refs
(AIAA PAPER 90-2148) Copyright

The results of a computational fluid dynamics investigation of two-dimensional ejector nozzles are presented. Scale model geometry and test data were obtained, and these scale models were then analyzed with HAWK Navier-Stokes code. Computational analyses were conducted with both a Baldwin-Lomax algebraic turbulence model and a two-equation k-k1 turbulence model. Flow field solutions for both single ejector slot and multiple ejector slot geometries were generated at several operating conditions. The results of the numerical analysis are compared wth experimental test data. Comparisons include thrust coefficients, air handling characteristics, and divergent section static pressure distributions. Results indicate that the two-equation turbulence model provides excellent agreement with experimental data for all configurations at both on-design and off-design conditions. The Baldwin-Lomax turbulence model generally provided good results for the single ejector slot configuration but was less effective in predicting the complex multiple shear layer flow field associated with the multiple ejector slot nozzle. Author

A90-42740*# Allied-Signal Aerospace Co., Phoenix, AZ.
MEASUREMENTS IN AN ANNULAR COMBUSTOR-DIFFUSER SYSTEM
R. SRINIVASAN, W. G. FREEMAN, S. MOZUMDAR, and J. W. GRAHMANN (Allied-Signal Aerospace Co., Garrett Engine Div., Phoenix, AZ) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 8 p. Research supported by NASA. refs
(Contract F33615-84-C-2427)
(AIAA PAPER 90-2162) Copyright

Results of three-component Laser Doppler Velocimeter (LDV) measurements in an annular combustor-diffuser system are presented in this paper. The LDV measurements were made at several locations in the prediffuser and dump regions of the combustor-diffuser test rig for three different inlet velocity profiles. The prediffuser average inlet Mach number was maintained at 0.305 during these tests. The LDV data are compared with predictions obtained from a boundary-fitted, two-dimensional elliptic analytical model. The agreement between the LDV data and the predicted results is very good for mean velocities. However, measured turbulence intensities are higher than the predicted values in the region adjacent to the prediffuser walls. Author

A90-42759#
UNSTEADY EULER ANALYSIS OF THE REDISTRIBUTION OF AN INLET TEMPERATURE DISTORTION IN A TURBINE
R. K. TAKAHASHI and R. H. NI (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 10 p. refs
(AIAA PAPER 90-2262) Copyright

Temperature migration behavior in rotor flow fields was analyzed using a three-dimensional unsteady Euler code in the effort to explain why rotor airfoil surfaces and passage endwalls experience higher than expected temperatures in engine environments. The time-averaged unsteady solution shows the hotter gas tending to migrate toward the rotor pressure side and the colder gas toward the suction side. Secondary flow vortices transport the hotter gas toward the inner and outer endwalls. Time-averaged temperature patterns show very good agreement with those observed in experiments, indicating that the Euler code is capturing at least the first-order physics of the temperature redistribution process. Author

A90-42761#
EFFECTS OF INLET TURBULENCE SCALE ON TURBINE BLADE SURFACE HEAT TRANSFER IN A LINEAR CASCADE
LELLO GALASSI, PAUL I. KING, and WILLIAM C. ELROD (USAF, Air Force Institute of Technology, Wright-Patterson AFB, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 13 p. refs
(AIAA PAPER 90-2264)

Heat transfer in a turbine cascade was examined for turbulence scale effects. The turbulence integral scale and microscale lengths of the free-stream flow were controlled by air-jet injection through a grid placed in the free-stream flow. Air was injected into the flow in three primary directions: co-flow, cross-flow, and counter-flow, at several injection pressures. Surface pressures on a turbine blade, surface heat transfer, turbulence intensity, and turbulence scale were obtained for two grid locations. Turbulence integral scale and microscale lengths were measured in two coordinates and heat transfer on a turbine blade was correlated with scale lengths. Author

A90-42763#
AN EXPERIMENTAL INVESTIGATION OF FILM COOLING EFFECTIVENESS FOR SLOTS OF VARIOUS EXIT GEOMETRIES
M. E. TASLIM (Northeastern University, Boston, MA), S. D. SPRING, and B. P. MEHLMAN (GE Aircraft Engines, Lynn, MA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 9 p. refs
(AIAA PAPER 90-2266) Copyright

The effect different slot geometries have on film effectiveness in the vicinity of slot breakout region is studied. Four different slot lip thickness to height ratios (t/s) and three different slot width to height ratios (w/s) are tested over a blowing ratio range of 0 to 1.3. All geometries are tested at a constant density ratio of 1.4. Slot surface film effectiveness measurements are made over a range of downstream surface distance to slot ratios of 0 to 15. Five different density ratios, spanning the typical engine operating range, are tested for one geometry to determine the effect of density ratio on film effectiveness. The results show that film effectiveness is highly sensitive to t/s but not significantly sensitive to either w/s or density ratio, and that an optimum injection angle of 8.5 deg exists for nondimensionalized downstream distance values less than 60. V.T.

A90-42773#
NUMERICAL SIMULATION OF DROPLET DEFORMATION IN CONVECTIVE FLOWS
ZHENG-TAO DENG and SAN-MOU JENG (Tennessee, University, Tullahoma) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 12 p. refs (AIAA PAPER 90-2309) Copyright

A computational model based on an Arbitrary-Lagrangian-Eulerian numerical algorithm has been developed for flows separated by a free surface where the surface tension force is important. This model was used to study deformation and oscillation of cylindrical/spherical droplets with and without external forced convection. The calculated frequency of droplet oscillation agrees well with the analytical value derived from perturbation analysis, and the amplitude of oscillation is not decaying with time which indicates that numerical diffusion and damping does not exist in the adopted algorithm. The deformation of an initially spherical droplet under forced convection was calculated and found consistent with the conclusions in the literature. Good agreement also has been obtained in comparison with experimental results for an initially deformed droplet under forced convection. Author

A90-42782*# United Technologies Research Center, East Hartford, CT.
UNSTEADY ANALYSIS OF HOT STREAK MIGRATION IN A TURBINE STAGE
DANIEL J. DORNEY, ROGER L. DAVIS, DAVID E. EDWARDS (United Technologies Research Center, East Hartford, CT), and NATERI K. MADAVAN (NASA, Ames Research Center, Moffett Field, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 15 p. Research supported by the U.S. Navy and United Technologies Corp. refs (AIAA PAPER 90-2354) Copyright

Two- and three-dimensional Navier-Stokes analyses are used to predict unsteady viscous rotor-stator interacting flow in the presence of a combustor hot streak. Predicted results are presented for a two-dimensional three-stator/four-rotor, a two-dimensional one-stator/one-rotor, and a three-dimensional one-stator/one-rotor simulation of hot streak migration through a turbine stage. Comparison of these results with experimental data demonstrates the capability of the three-dimensional procedure to capture most of the flow physics associated with hot streak migration including the effects of combustor hot streaks on turbine rotor surface temperatures. It is noted that blade count ratio has little effect on predicted time-averaged surface pressure and temperature distributions, but a substantial effect on the unsteady flow characteristics. It is shown that high-temperature hot streak fluid accumulates on the pressure surface of the rotor blades, resulting in a high time-averaged surface temperature 'hot spots'. V.T.

A90-42870
DEVELOPMENTS IN MECHANICS. VOLUME 15 - MIDWESTERN MECHANICS CONFERENCE, 21ST, MICHIGAN TECHNOLOGICAL UNIVERSITY, HOUGHTON, AUG. 13-16, 1989, PROCEEDINGS
JOHN B. LIGON, ED., H. W. LORD, ED., MADHUKAR VABLE, ED., VIRGIL W. SNYDER, ED., and GEORGE TREVINO, ED. (Michigan Technological University, Houghton) Conference sponsored by Michigan Technological University, Ford Motor Co., and General Motors Corp. Houghton, MI, Michigan Technological University, 1989, 597 p. For individual items see A90-42871 to A90-42875.

Recent experimental and analytical investigations in mechanics are discussed in reviews and reports. Topics addressed include smart CFD algorithms and adaptivity, the supersonic/hypersonic laminar-turbulent transition, cyclic plastic-strain measurements at a notch root under fully reversed loading, a new class of random processes applicable to helicopter noise, the buckling of thin-walled beams, gravity-decoupled robots, and the elastic stability of orthotropic plates under a follower force. Consideration is given to interlaminar stresses in thick-section composite plates and shells, the design of structural joints for dynamic response, forced shear-wave propagation in a layered viscoelastic half-space, the mechanical properties of sea ice, an experimental modal-analysis technique for large structures, boundary-layer flow of a particle-fluid suspension past a flat plate, slow crack growth in thermoplastic welds, BEMs for linear elasticity, and the effect of vibration on heat-transfer rate. T.K.

A90-42911
DEVELOPMENT OF A MATHEMATICAL MODEL OF AN ADAPTIVE ANTIFLUTTER SYSTEM [K FORMIROVANIIU MATEMATICHESKOI MODELI ADAPTIVNOI PROTIVOFLATTERNOI SISTEMY]
B. O. KACHANOV, S. I. OVCHARENKO, and A. T. PONOMAREV (Voenno-Vozdushnaia Inzhenernaia Akademiia, Moscow, USSR) Prikladnaia Mekhanika (ISSN 0032-8243), vol. 26, Jan. 1990, p. 113-119. In Russian. refs
Copyright

The principles of the development of a mathematical model of aeroautoelasticity with an adaptive antiflutter system are presented. The main part of the aeroautoelasticity problem is formulated using the convolution integral. The aircraft deformations are expressed in terms of eigenfunctions; generalized aerodynamic forces are determined on the basis of numerical solutions of canonic equations using methods of nonlinear aerodynamics. The aeroelasticity model is supplemented by linear transducer and drive models. The coefficients of the synthesized model are refined through discrete observations using an identification algorithm. A specific example is presented. V.L.

A90-43039
SOME TECHNOLOGICAL ERRORS IN THE USE OF CAPILLARY INSPECTION IN GAS TURBINE ENGINE REPAIR [NEKOTORYE TEKHNOLOGICHESKIE OSHIBKI PRIMENENIIA KAPILLIARNOGO KONTROLIA PRI REMONTE GTD]
IU. A. GLAZKOV Defektoskopiia (ISSN 0130-3082), no. 3, 1990, p. 63-69. In Russian. refs
Copyright

Some typical errors committed during the capillary inspection of gas turbine components in gas turbine engine repair shops are examined. The errors discussed are primarily associated with the application and removal of penetrants, application of the developer, examination of parts and components, and preparation of parts and components for the inspection. Specific errors are illustrated by photographs, and correct test procedures are described. V.L.

A90-43285
SPECTRAL RESPONSE OF A UV FLAME SENSOR FOR A MODERN TURBOJET AIRCRAFT ENGINE
WILLIAM E. SCHNEIDER (Optronic Laboratories, Inc., Orlando, FL) and GEORGE L. MINOTT (Armtec Industries, Inc., Manchester, NH) IN: Ultraviolet technology III; Proceedings of the Meeting, San Diego, CA, Aug. 10, 11, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 290-310. refs
Copyright

A flame sensor is incorporated into the F404 turbojet's afterburner section in order to monitor operations. The sensor contains a gaseous-discharge-type UV detector tube. Attention is presently given to the results of a study of the relationship between the flame and the sensor at temperatures of up to 400 F, using a double monochromator-based spectroradiometric system optimized for spectral response measurements in the 200-300 nm wavelength range. Modifications have been instituted as a result of these tests which guarantee a sufficiently high sensor output signal level, irrespective of variability in afterburner flame irradiance associated with differences in engine operating conditions. O.C.

A90-43309#
DEICING OF SOLIDS USING RADIANT HEATING
B. SONG and R. VISKANTA (Purdue University, West Lafayette, IN) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 4, July 1990, p. 311-317. Research supported by China Flight Test Research Center. Previously cited in issue 18,

p. 2819, Accession no. A89-43231. refs
Copyright

A90-43729
COMBINING THERMAL AND HIGH LEVEL ACOUSTICS
HALIEN R. BESAW (U.S. Navy, Pacific Missile Test Center, Point Mugu, CA) IN: Institute of Environmental Sciences, Annual Technical Meeting, 35th, Anaheim, CA, May 1-5, 1989, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1989, p. 38-42.
Copyright

A novel, very realistic missile reliability test method has been developed and documented by MIL-STD-810D, Method 523. The method involves the simultaneous subjection of the test article to acoustic vibration and thermal conditioning; several methods have been used to force the conditioned air around the test vehicle in a way that minimizes interference with the acoustical effect. Liquid nitrogen can be used in the temperature conditioning process to improve the cooling ramps required by the test profile. A box frame with polyethylene flexible foam shroud material furnishes an adequate short-term test method. O.C.

A90-43734
FATIGUE LIFE ASSESSMENT OF A LEADED ELECTRONIC COMPONENT UNDER A COMBINED THERMAL AND RANDOM VIBRATION ENVIRONMENT
H. S. GOPALAKRISHNA and JERRY METCALF (KIT Corp., Saint Paul, MN) IN: Institute of Environmental Sciences, Annual Technical Meeting, 35th, Anaheim, CA, May 1-5, 1989, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1989, p. 110-118. refs
Copyright

This paper describes procedures that have been developed to predict the fatigue life of a leaded electronic component subjected to a combined thermal and random vibration environment. Validation of the finite element models and the analysis procedures were ensured by conducting various correlations to experimental data. The location of the highest stressed lead under vibrational loading was determined by considering the relative amount of circuit card curvature exhibited at the primary resonant frequencies of the module. Author

A90-44147* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AERODYNAMIC APPLICATIONS OF INFRARED THERMOGRAPHY
KAMRAN DARYABEIGI and DAVID W. ALDERFER (NASA, Langley Research Center, Hampton, VA) IN: Infrared technology XV; Proceedings of the Meeting, San Diego, CA, Aug. 7-9, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 166-175. refs
Copyright

A series of wind tunnel experiments were conducted as part of a systematic study for evaluation of infrared thermography as a viable non-intrusive thermal measurement technique for aerodynamic applications. The experiments consisted of obtaining steady-state surface temperature and convective heat transfer rates for a uniformly heated cylinder in transverse flow with a Reynolds number range of 46,000 to 250,000. The calculated convective heat transfer rates were in general agreement with classical data. Furthermore, IR thermography provided valuable real-time fluid dynamic information such as visualization of flow separation, transition and vortices. Author

A90-44325
THERMAL NONDESTRUCTIVE CHARACTERIZATION OF THE INTEGRITY OF PROTECTIVE COATINGS
JANE W. MACLACHLAN SPICER, LEONARD C. AAMODT, and JOHN C. MURPHY (Johns Hopkins University, Laurel, MD) Johns Hopkins APL Technical Digest (ISSN 0270-5214), vol. 11, Jan.-June 1990, p. 175-179. Research supported by U.S. Navy. refs
(Contract F33615-87-C-5221)
Copyright

A description is provided of the Applied Physical Laboratory's most recent results in the development of thermal characterization techniques, specifically the nondestructive thermal inspection technique of time-resolved infrared radiometry (TRIR). Advantages of the TRIR technique include the ability to simultaneously provide thickness measurement and disbond detection and also to measure multilayer systems and degree of disbonding. A schematic diagram of the system used for TRIR measurements is provided, and types and methods of measurement are discussed. It is noted that theoretical modeling has been an important part of this program, providing insights into the variations in coating-substrate bonding and coating properties. TRIR measurements can be analyzed in temperature-time line scans, and these data can be compared with one- and three-dimensional models. L.K.S.

A90-44431
NUMERICAL SIMULATION OF THE COMPRESSIBLE FLOW IN A VALVE-CYLINDER ASSEMBLY
A. KOURTA (European Center for Research and Advanced Training in Scientific Computing, Toulouse, France), H. HA MINH (Ecole Nationale Superieure d'Electrotechnique, d'Electronique, d'Informatique et d'Hydraulique, Toulous, France), and D. VANDOMME (Rouen, Institut National des Sciences Appliquees, Mont-Saint-Aignan, France) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 1. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 589-594. refs
Copyright

Unsteady compressible flow in a simple valve-cylinder configuration is simulated numerically. The Navier-Stokes equations are solved by means of an implicit two-step MacCormack method with finite-volume discretization, second-order-accurate flux splitting (Steger and Warming, 1982), and line-Gauss-Seidel relaxation; the model of Baldwin and Lomax (1978) is used to describe turbulence. The derivation of the method is outlined, and results are presented in graphs for (1) two-dimensional laminar flow, (2) axisymmetric laminar flow, and (3) axisymmetric turbulent flow. Significant differences are found between (1) and (2), with lower jet momentum and main circulation separated from the upper boundary in case (2); case (3) differs only slightly from (2), but the simulation fails to predict wall heat transfer accurately. The applicability of the method to the design of advanced internal-combustion engines is indicated. T.K.

A90-44457
A WEIGHTED RESIDUAL FORMULATION FOR FINITE ELEMENT SOLUTIONS OF THE STEADY EULER EQUATIONS
Z. FANG and A. J. SABER (Concordia University, Montreal, Canada) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 2. Southampton, England and New York/Berlin, Computational Mechanics Publications/Springer-Verlag, 1989, p. 419-425. refs
Copyright

A finite element formulation of the first order partial differential equations of gas dynamics is solved by using a second order embedded method. The discretized nonlinear simultaneous equations developed by this formulation are well-suited to iterative solution procedures and can be solved by a positive matrix solver. The numerical procedure converges in eleven iterations without angle of attack and about forty iterations with angle of attack. Results compare with experimental data. Author

A90-44464
NUMERICAL PREDICTIONS FOR THE FLOW AND THE HEAT TRANSFER IN GAS TURBINE COOLING SYSTEMS
A. RANDRIAMAMPIANINA, A. CHAOUCHE, E. SEGURA, and P. BONTOUX (Aix Marseille II, Universite, Marseille, France) IN: International Symposium on Numerical Methods in Engineering, 5th, Lausanne, Switzerland, Sept. 11-15, 1989, Proceedings. Volume 2. Southampton, England and New York/Berlin,

Computational Mechanics Publications/Springer-Verlag, 1989, p. 525-531. refs
Copyright

A numerical prediction study is presented of the flow and heat transfer of a Boussinesq fluid in a differentially heated annular cavity using a Tau-Chebyshev technique. The Boussinesq relation is applied to the gravity, centrifugal, and Coriolis accelerations. The isothermal flow of an incompressible fluid inside a closed rotor-stator system is also studied for the purpose of determining the efficiency of a spectral Tau-Chebyshev method in the presence of a discontinuity. The spectral method is compared with finite difference results and theoretical solutions of Daily and Nece (1960). Finally, the effect of the axial inflow of cooling air in a differentially heated rotor-stator system is analyzed when the gravitational acceleration is neglected in comparison to the centrifugal acceleration. Particular attention is given to the problem of the ingestion of hot mainstream gas into the cavity between the rotating and stationary turbine disks in order to determine the minimum amount of cooling air necessary to prevent this. All of the computations are carried out on the Cray 2 vector computer. S.A.V.

A90-44606
AIRCRAFT ENGINE INSPECTION
RICHARD H. BURKEL (GE Aircraft Engines, Cincinnati, OH) Aerospace Engineering (ISSN 0736-2536), vol. 10, Aug. 1990, p. 39-41.
Copyright

The inspection of new and in-service parts such as compressor blades is integral to the operations of engine manufacturers and operators alike. Subject to cracking from high temperatures and stresses, these blades must be inspected for minute cracks and surface-connected porosity at regular periods, during their entire service life. Conventional manual fluorescent penetrant inspection (FPI) is the generally accepted method for detecting these surface flaws. However, results can vary substantially, depending on the inspector's skill, experience, and human error factors. The USAF has initiated development of an integrated blade inspection system that calls for automated X-ray and infrared blade inspection systems, which have been developed along with automated FPI. Further developments have allowed all of the processing steps to be handled automatically and has led to replication of the human inspector's process of both scanning the part and evaluating any discrepancies. Finally, success with advanced FPI systems is leading to research for a larger automated system which would be capable of detecting surface flaws in larger engine parts, such as turbofan disks, compressors, and turbines. R.E.P.

A90-44730*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NASA INVESTIGATION OF A CLAIMED 'OVERLAP' BETWEEN TWO GUST RESPONSE ANALYSIS METHODS
BOYD PERRY, III, JESSICA A. WOODS (NASA, Langley Research Center, Hampton, VA), and ANTHONY S. POTOTZKY (Planning Research Corp., Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 27, July 1990, p. 605-611. Previously cited in issue 12, p. 1859, Accession no. A89-30851. refs
Copyright

A90-44755
THE FLOW FIELD AND HEAT TRANSFER NEAR A TURBULATOR
BRYAN R. BECKER (Missouri, University, Kansas City) and CAROL S. BECKER (BECO, Blue Springs, MO) International Communications in Heat and Mass Transfer (ISSN 0735-1933), vol. 17, July-Aug. 1990, p. 455-464. refs
Copyright

A detailed two-dimensional numerical study of the fluid flow and heat transfer near a single turbulator within a short straight section of a turbine blade internal cooling passage is described. Axial distributions of local skin friction, Stanton number, and Nusselt number are given, as well as profiles of velocity and temperature and contours of streamfunction. The numerical results are found to be in good agreement with the experimental results published by Han et al. (1986). Author

A90-45133
A STUDY OF THE ERRORS OF A GYROSCOPIC INSTRUMENT FOR MEASURING LINEAR ACCELERATIONS [OB ISSLEDOVANII POGRESHNOSTEI GIROSKOPICHESKOGO IZMERITELIA LINEINYKH USKORENII]
E. N. BEZVESIL'NAIA (Kievskii Politekhnicheskii Institut, Kiev, Ukrainian SSR) Prikladnaia Mekhanika (ISSN 0032-8243), vol. 26, March 1990, p. 103-110. In Russian. refs
Copyright

A gyroscopic instrument is described which is capable of measuring linear accelerations with a high precision. The system determines the value of gravity along the flight path and employs a three-degree-of-freedom unbalanced gyroscope containing an interframe correction system and other elements. The precision of the sensor element of the system is evaluated, and equations of motion are derived. V.L.

A90-45225
DEVELOPMENT OF PROCESS CONTROL PROCEDURE FOR ULTRAHIGH-SENSITIVITY FLUORESCENT PENETRANT INSPECTION SYSTEMS
J. A. WEIN and T. C. KESSLER (GE Aircraft Engines, Cincinnati, OH) Materials Evaluation (ISSN 0025-5327), vol. 48, Aug. 1990, p. 991-994.
Copyright

A process control procedure that employs a very sensitive fluorescent penetrant inspection (FPI) was developed, together with a set of known-defect test specimens manufactured from 6Al-4V titanium alloy. It is shown that, using this procedure for a series of inspections at specified time intervals, it is possible to detect the development of a crack in a turbine disk before the crack had reached anywhere near a critical length. It was possible to find LCF cracks in parts that exhibited pinpoint crack indications on the order of 0.13 mm length. I.S.

A90-45281
PRELIMINARY DESIGN AND LOAD DISTRIBUTIONS OF HIGH PERFORMANCE MECHANICAL SYSTEMS
J.-F. RIGAL and D. PLAY (Lyon, Institut National des Sciences Appliquees, Villeurbanne, France) IN: Computers in engineering 1989; Proceedings of the ASME International Computers in Engineering Conference and Exposition, Anaheim, CA, July 30-Aug. 3, 1989. Volume 2. New York, American Society of Mechanical Engineers, 1989, p. 93-103. Research supported by the Aerospatiale Marignane. refs
Copyright

A new approach to modeling mechanical systems is proposed which follows the FEM principle. An application to self-aligning spherical roller bearings of planet gears mounted on an epicyclic gear train is presented. Interactions between overloads on rolling elements and tooth contact conditions of the planet are also presented. An example involving the principal power transmission gear box of a helicopter is considered. C.D.

A90-45300
TOOTH THICKNESS EFFECTS ON THE PERFORMANCE OF GAS LABYRINTH SEALS
D. L. RHODE and R. I. HIBBS (Texas A & M University, College Station) IN: Computers in engineering 1989; Proceedings of the ASME International Computers in Engineering Conference and Exposition, Anaheim, CA, July 30-Aug. 3, 1989. Volume 2. New York, American Society of Mechanical Engineers, 1989, p. 429-435. refs
Copyright

A previously developed finite difference computer code was revised to allow the specification of upstream and downsteam reservoir conditions as boundary conditions, whereas the domain extends only from the seal inlet to outlet plane. The required execution CPU time is only approximately one hour on a VAX

8800 computer for three-cavity, straight-through seals. A parametric study focusing on tooth thickness showed that streamwise swirl development was only slightly higher for the thickest tooth. Further, for such straight-through seals it was found that leakage is almost independent of tooth thickness and that the second cavity yields a definite increase in turbulence energy and turbulence length scale over the first cavity. Author

A90-45324* Virginia Polytechnic Inst. and State Univ., Blacksburg.
FATIGUE LIFE ESTIMATES FOR HELICOPTER LOADING SPECTRA
A. K. KHOSROVANEH, N. E. DOWLING (Virginia Polytechnic Institute and State University, Blacksburg), A. P. BERENS, and J. P. GALLAGHER (Dayton, University, OH) American Helicopter Society, Journal (ISSN 0002-8711), vol. 35, July 1990, p. 59-67. Research supported by the U.S. Army. Previously announced in STAR as N90-16294. refs
(Contract NAG1-822)
Copyright

Helicopter loading histories applied to notch metal samples are used as examples, and their fatigue lives are calculated by using a simplified version of the local strain approach. This simplified method has the advantage that it requires knowing the loading history in only the reduced form of ranges and means and number of cycles from the rain-flow cycle counting method. The calculated lives compare favorably with test data. Author

A90-45430
CERTIFICATION OF COMPOSITES FOR COMMERCIAL AIRCRAFT
CURTIS R. DAVIES (Gulfstream Aerospace Corp., Savannah, GA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 12 p. refs
(SAE PAPER 892212) Copyright

The increased use of composites in commercial aviation industry has created increased awareness of the effort required for development of certified structures. The criteria used to certify a structure has increased in complexity for certain requirements and eased in others. This is a result of the continuing use of advanced composites in commercially certified structures. While there is dispute over the extent of future advanced composite applications, it will be required on increasing amounts of commercial aviation structure. Current certification regulations and standard practices, used for compliance to those regulations, are reviewed. This paper is intended to give an overview for the scope of composite certification activity. Author

A90-45482
LARGE-ORDER MODAL ANALYSIS TECHNIQUES IN THE AEROELASTIC DESIGN OPTIMIZATION PROGRAM (ADOP)
TSAIR-JYH TZONG, GREGORY D. SIKES, and MATTI J. LOIKKANEN (Douglas Aircraft Co., Long Beach, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 13 p. refs
(SAE PAPER 892323) Copyright

A large-order modal analysis capability has been incorporated in the Aeroelastic Design Optimization Program (ADOP). This module includes an accelerated subspace iteration scheme with modifications to the numerical error correction technique and some improvements in computational efficiency. Special considerations are presented for solving large size problems, such as a set of equations stored in an envelope format, large matrix blocking, finite-element node renumbering, and automated structural model correction. Rigid body modes may be computed independently of the modal analysis to reduce the cost of the eigenvalue solution. Small and large numerical examples are presented to demonstrate the effectiveness of the modal analysis technique. Author

A90-45528
A UNIFIED PRESSURE CORRECTION ALGORITHM FOR COMPUTING COMPLEX FLUID FLOWS
WEI SHYY (GE Corporate Research and Development Center, Schenectady, NY) IN: Recent advances in computational fluid dynamics; Proceedings of the US/ROC (Taiwan) Joint Workshop, Princeton, NJ, May 23-25, 1988. Berlin and New York, Springer-Verlag, 1989, p. 135-147. refs
Copyright

An overview is given of recent research progress in developing a unified numerical algorithm capable of solving flow over a wide range of Mach and Reynolds numbers in complex geometries. The algorithm is based on the pressure correction method, combined treatment of the Cartesian and contravariant velocity components on arbitrary coordinates, and second-order accurate discretization. A number of two- and three-dimensional flow problems including the effects of turbulence, combustion, and compressibility are presented to demonstrate the capability of the present algorithm. Author

A90-45534
LARGE-EDDY SIMULATIONS OF FLOWS IN A RAMJET COMBUSTOR
WEN-HUEI JOU and SURESH MENON (Flow Research, Inc., Kent, WA) IN: Recent advances in computational fluid dynamics; Proceedings of the US/ROC (Taiwan) Joint Workshop, Princeton, NJ, May 23-25, 1988. Berlin and New York, Springer-Verlag, 1989, p. 334-376. refs
(Contract N00014-84-C-0359)
Copyright

The oscillatory cold flow in a ramjet combustor configuration is presently addressed by a numerical simulation method which gives attention to the interaction between the flowfield's vorticity and acoustic components, when the reduced frequency of the flow, based on the speed of sound, is of the order of unity. The numerical model has indicated that the combustor's interior must be isolated from the external region region by a choked nozzle. The numerical simulations thus obtained are able to exclude the effects of artificially imposed outflow-boundary conditions. The unsteady flow fields near the shear layer separation point in the nozzle region are investigated. O.C.

A90-45728
NAVIER-STOKES COMPUTATIONS OF THREE-DIMENSIONAL LAMINAR FLOWS WITH BUOYANCY IN A CHANNEL WITH WING-TYPE VORTEX GENERATORS
GAUTAM BISWAS, NIMAI KUMAR MITRA, and MARTIN FIEBIG IN: Advances in fluid dynamics. New York, Springer-Verlag, 1989, p. 11-24. refs
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A numerical investigation of mixed convection flow structure and heat transfer in a rectangular channel with a built-in slender delta wing is reported. It is shown that heat transfer can be increased significantly in channel flows by generating longitudinal vortices with wing-type vortex generators. Free convection causes a further augmentation of heat transfer. C.D.

A90-45759
FLOW AND HEAT TRANSFER IN ROTATING-DISC SYSTEMS. VOLUME I - ROTOR-STATOR SYSTEMS
J. M. OWEN and R. H. ROGER (Sussex, University, Brighton, England) Research supported by Rolls Royce, PLC, Ruston Gas Turbines, PLC, and SERC. Taunton, England/New York, Research Studies Press, Ltd./John Wiley and Sons (Mechanical Engineering Research Studies: Engineering Design Series, No. 1), 1989, 299 p. refs
Copyright

The rotating flows occurring inside turbomachinery are discussed. Laminar and turbulent flow over a single disk and heat transfer from a single disk are addressed. Rotor-stator systems with and without superposed flow, heat transfer in rotor-stator systems, and the ingress problem of sealing rotor-stator systems are examined. C.D.

A90-45769
ADVANCED APPLICATIONS OF BEM TO GAS TURBINE ENGINE STRUCTURES

R. B. WILSON, N. MILLER (United Technologies Corp., Pratt and Whitney Group, Hartford, CT), and P. K. BANERJEE (New York, State University, Buffalo) IN: Industrial applications of boundary element methods. London and New York, Elsevier Applied Science, 1989, p. 1-37. refs
Copyright

Features of an advanced three-dimensional stress analysis code based on BEM for elastic, inelastic, and vibration analyses of multizone or substructured three-dimensional solids are presented. The elastic analyses have been evolved for isotropic or cross-anisotropic media with thermal and centrifugal loading. The inelastic analyses include kinematic plasticity with multiple yield surfaces and isotropic plasticity with variable hardening. Free-vibration analysis is developed only for the isotropic three-dimensional solid. The examples shown demonstrate that many of the potentials of BEM as a superior stress analysis tool are now being realized. R.E.P.

A90-45788
EFFECT OF AERODYNAMIC HEATING ON DEFORMATION OF COMPOSITE CYLINDRICAL PANELS IN A GAS FLOW
VICTOR BIRMAN (Missouri, University, Saint Louis), CHARLES W. BERT (Oklahoma, University, Norman), and ISAAC ELISHAKOFF (Florida Atlantic University, Boca Raton) Composite Structures (ISSN 0263-8223), vol. 15, no. 3, 1990, p. 259-273. refs
Copyright

In this paper, motions of composite cylindrical panels in a gas flow are considered. It is shown that the main factor contributing to large static deformations is a nonuniform aerodynamic heating, while aerodynamic pressure is of secondary importance, at high Mach number. It was found that the main factor resulting in the increase of deformations is the nonuniform distribution of temperature along the curved edges. Deformations decrease rapidly in shallower panels. Nonuniformly heated panels become unstable at the values of axial compressive load, which are much smaller than the static buckling value calculated in the absence of heating. The condition of panel flutter of nonuniformly heated composite panels in a gas flow is also formulated. Author

N90-25084# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (Germany, F.R.). Unternehmensbereich Transport und Verkehrsflugzeuge.
SHORT TIME-DYNAMOMETER SYSTEM FOR SHOCK WAVE CHANNELS [KURZZEIT-KRAFTMESSSYSTEM (SFS) FUER STOSSWELLENKANAELE (LESS THAN 10 MS)]
JOSEPH MERTENS and KLAUS KOENIG *In its* Research and Development: Technical and Scientific Publications 1989 p 63-68 1989 In GERMAN Presented at DGLR-Fachausschusses Versuchswesen der Fluid- und Thermodynamik, Goettigen, Federal Republic of Germany, 1989
(MBB-UT-115/89-PUB) Avail: NTIS HC A15/MF A02

A system for the measurement of aerodynamic forces and moments is developed, based mainly on acceleration. The modal analysis and the optimization of the model is done by finite element calculations. The check of the modal characteristics of the model is done by vibration tests and improvement of the finite element modelization. The influence matrices are calculated with consideration of the calibration tests. A vibration test allows the estimation of the acceleration measurement and improvement of the modelization. ESA

N90-25254# Wichita State Univ., KS. Dept. of Mechanical Engineering.
MECHANICAL PAINT REMOVAL TECHNIQUES FOR AIRCRAFT STRUCTURES M.S. Thesis
J. P. AMRO Dec. 1989 97 p
(IAR-89-23) Avail: NTIS HC A05/MF A01

Paint removal was studied by mechanical means, i.e., blasting, from aluminum structural aeronautical materials (2024-T3) and the changes on the surface morphology introduced by the paint removal process are examined. The principal experimental parameters are particle velocity, and particle angle of incidence. An ideal combination of these parameters could yield a stripped aircraft skin substrate with minimal or no damage. Three types of plastic particles were used are: Polyextra, Polyplus, and Type III. Scanning electron microscopy has shown that a potentially damaging surface morphology is formed on the surface of the structural material. Multiple microcracks or fissures generated by the stripping could reduce the life and/or change the engineering properties of the material. It as also found that aluminum material stripped using plastic media particles has a very rough surface that may affect the aerodynamic flow of an airplane. The number of microcracks and degree of surface roughness vary with the particle impact angle and velocity. To minimize or eliminate the damage done to the surface during the plastic particle stripping, it was necessary to change the blasting media to softer and smaller particles. Commercial wheat flour was selected for this purpose. With the substitution of these natural particles, the scanning electron microscopy observations of the stripped surface revealed no potential damage (microcracks or fissures) on the structural material, and the surface roughness was also reduced. Author

N90-25267# European Space Agency, Paris (France).
A DECISION-MAKING AID FOR MULTI-LAYER RADAR ABSORBENT COVERINGS
ANNIE BASTIERE (Office National d'Etudes et de Recherches Aerospatiales, Paris, France) May 1990 291 p Transl. into ENGLISH from Elaboration d'une methode d'aide a la decision pour la realisation de materiaux absorbants radar (Paris, France, ONERA), 1989 249 p Original language document was announced as N89-28703
(ESA-TT-1173; ONERA-NT-1989-2; ETN-90-97078) Avail: NTIS HC A13/MF A02

A multi-criteria optimization method for manufacture of multi-layer radar-absorbent materials intended for cladding of aircraft is presented. This entails firstly the application of an optimization method by nonlinear constraints, the generalized projected gradient; secondly, theoretical and computer-aided application of a decision-making facility employing several different criteria and fusion laws. These laws are obtained by means of two mathematical methods: the first is based on Dempster and Shafer's evidence theory; the other is derived from fuzzy set theory. Several applications of the proposed method, involving firstly triple-layer materials from the same class and secondly materials from different classes whose quantity of layers varies from 1 to 5, are presented. ESA

N90-25289*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EFFECT OF VANE TWIST ON THE PERFORMANCE OF DOME SWIRLERS FOR GAS TURBINE AIRBLAST ATOMIZERS
GERALD J. MICKLOW, ANJU S. DOGRA (Florida Univ., Gainesville.), and H. LEE NGUYEN Jun. 1990 15 p Presented at the 26th Joint Propulsion Conference, Orlando, FL, 16-18 Jul. 1990; sponsored in part by AIAA, SAE, ASME, and ASEE Original contains color illustrations
(NASA-TM-103195; E-5589; NAS 1.15:103195; AIAA-90-1955) Avail: NTIS HC A03/MF A01; 1 functional color page CSCL 20/4

For advanced gas turbine engines, two combustor systems, the lean premixed/prevaporized (LPP) and the rich burn/quick quench/lean burn (RQL) offer great potential for reducing NO(x) emissions. An important consideration for either concept is the development of an advanced fuel injection system that will provide a stable, efficient, and very uniform combustion system over a wide operating range. High-shear airblast fuel injectors for gas turbine combustors have exhibited superior atomization and mixing compared with pressure-atomizing fuel injectors. This improved mixing has lowered NO(x) emissions and the pattern factor, and has enabled combustors to alternate fuels while maintaining a stable, efficient combustion system. The performance of high-shear airblast fuel injectors is highly dependent on the design of the dome swirl vanes. The type of swirl vanes most widely used in gas turbine combustors are usually flat for ease of manufacture, but vanes with curvature will, in general, give superior aerodynamic

performance. The design and performance of high-turning, low-loss curved dome swirl vanes with twist along the span are investigated. The twist induces a secondary vortex flow pattern which will improve the atomization of the fuel, thereby producing a more uniform fuel-air distribution. This uniform distribution will increase combustion efficiency while lowering NO(x) emissions. A systematic swirl vane design system is presented based on one-, two-, and three-dimensional flowfield calculations, with variations in vane-turning angle, rate of turning, vane solidity, and vane twist as design parameters. Author

N90-25291*# Pennsylvania State Univ., University Park. Dept. of Aerospace Engineering.
A COMPUTATIONAL EFFICIENT MODELLING OF LAMINAR SEPARATION BUBBLES Final Report
PAOLO DINI and MARK D. MAUGHMER Jul. 1990 167 p (Contract NAG1-778)
(NASA-CR-186729; NAS 1.26:186729) Avail: NTIS HC A08/MF A01 CSCL 20/4

In predicting the aerodynamic characteristics of airfoils operating at low Reynolds numbers, it is often important to account for the effects of laminar (transitional) separation bubbles. Previous approaches to the modelling of this viscous phenomenon range from fast but sometimes unreliable empirical correlations for the length of the bubble and the associated increase in momentum thickness, to more accurate but significantly slower displacement-thickness iteration methods employing inverse boundary-layer formulations in the separated regions. Since the penalty in computational time associated with the more general methods is unacceptable for airfoil design applications, use of an accurate yet computationally efficient model is highly desirable. To this end, a semi-empirical bubble model was developed and incorporated into the Eppler and Somers airfoil design and analysis program. The generality and the efficiency was achieved by successfully approximating the local viscous/inviscid interaction, the transition location, and the turbulent reattachment process within the framework of an integral boundary-layer method. Comparisons of the predicted aerodynamic characteristics with experimental measurements for several airfoils show excellent and consistent agreement for Reynolds numbers from 2,000,000 down to 100,000. Author

N90-25332# European Space Agency, Paris (France).
CONSTRUCTION OF A HYBRID ANGULAR VELOCITY REFERENCE SYSTEM FOR INVESTIGATION OF THE DYNAMIC CHARACTERISTICS OF STRAPDOWN GYROS
HELMUT NIEDERSTRASSER (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick, Germany, F.R.) May 1990 77 p Transl. into ENGLISH from Aufbau einer hybriden Drehgeschwindigkeitsreferenz zur Untersuchung des Verhaltens von Strapdownkreiseln (Brunswick, Fed. Republic of Germany, DFVLR), Dec. 1988 76 p Original language document was announced as N90-12577
(ESA-TT-1181; DFVLR-FB-89-25; ETN-90-97081) Avail: NTIS HC A05/MF A01

A hybrid angular velocity reference system for dynamic gyro investigations with conventional single-axis turntable is described. The reference measurement system consists of an inductosyn, a tachometer and a linear accelerometer. The dynamic investigation of laser gyros by calculation of the power spectral densities of the gyro measurement error and the gyro's dynamic response is addressed. The characteristics of the test rig, the inherent dynamics of the turntable and its scope for correction, are discussed. ESA

N90-25348# Wichita State Univ., KS. Dept. of Mechanical Engineering.
A SIMULATION CODE FOR TURBOCOMPOUND DIESEL ENGINES Final Report
JAMES A. HARRIS and ALI M. YOUSSEF Nov. 1989 134 p (IAR-89-26) Avail: NTIS HC A07/MF A01

A FORTRAN computer code was developed to simulate the performance of a turbocompound two-stroke diesel engine. This powerplant offers the potential for fuel efficiency combined with high power-to-weight ratio, and is being considered for airborne applications such as helicopters and drone aircraft. The simulation code allows the user to specify engine parameters for the diesel core, the turbocharger (in the form of a performance curve), the bottoming turbine, and the intercooler. The program runs in two modes. The user runs the design mode first, in which specification parameters are set and the code sizes the turbomachinery and intercooler. The off-design mode can then be run to see how the resulting engine will perform at off-design values of ambient conditions, fueling rate, and engine speed. The code was developed to run on a IBM PC. Graphical interface programs allow the user to input parameters on a screen showing the engine schematic, and to display the simulated performance in various graphical formats. Author

N90-25361# Central Research Inst. of Electric Power Industry, Tokyo (Japan). Energy and Environment Lab.
STUDY ON APPLICATION OF ULTRASONIC WAVE MEASUREMENT TO CREEP-FATIGUE DAMAGE DETECTION
MASAAKI MATSUBARA and AKITO NITA Sep. 1988 30 p In JAPANESE; ENGLISH summary
(DE89-782317; CRIE-T-87046) Avail: NTIS (US Sales Only) HC A03/MF A01

Research was made to extend the lives of old thermal power plants. In order to grasp the secular deterioration situation by nondestructive technique, which is an important study item, possibility of detecting creep fatigue damage by applying ultrasonic wave measurement was studied. From reference survey, it was found that ultrasonic wave measurement might be effective for the detection of damages. But it was clear that it had never been applied to the detection of creep fatigue damages which are frequent in real rotors. By connecting a usual ultrasonic wave measuring system and a microcomputer, processing of spectrum analysis by Fourier transform was made possible. Imagining the actual stop-inspection restarting of plants, a creep fatigue monitoring sham test was carried out on the CrMoV forged steel collected from a real rotor. The ultrasonic wave velocity, and the relation between the attenuation constant and the life specific consumption were obtained by this test. In this way, possibility to detect creep fatigue damages by ultrasonic wave measurment became promising. DOE

N90-25368*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
BEHAVIOR OF COMPOSITE/METAL AIRCRAFT STRUCTURAL ELEMENTS AND COMPONENTS UNDER CRASH TYPE LOADS: WHAT ARE THEY TELLING US
HUEY D. CARDEN, RICHARD L. BOITNOTT, and EDWIN L. FASANELLA (Lockheed Engineering and Sciences Co., Hampton, VA.) May 1990 16 p
(NASA-TM-102681; NAS 1.15:102681;
USAAVSCOM-TR-90-B-003) Avail: NTIS HC A03/MF A01
CSCL 20/11

Failure behavior results are presented from crash dynamics research using concepts of aircraft elements and substructure not necessarily designed or optimized for energy absorption or crash loading considerations. To achieve desired new designs which incorporate improved energy absorption capabilities often requires an understanding of how more conventional designs behave under crash loadings. Experimental and analytical data are presented which indicate some general trends in the failure behavior of a class of composite structures which include individual fuselage frames, skeleton subfloors with stringers and floor beams but without skin covering, and subfloors with skin added to the frame-stringer arrangement. Although the behavior is complex, a strong similarity in the static and dynamic failure behavior among these structures is illustrated through photographs of the experimental results and through analytical data of generic composite structural models. It is believed that the similarity in behavior is giving the designer and dynamists much information about what to expect in the crash behavior of these structures and can guide designs for improving the energy absorption and crash behavior of such structures. Author

N90-25375*# Sikorsky Aircraft, Stratford, CT.
CALCULATION OF FLIGHT VIBRATION LEVELS OF THE AH-1G HELICOPTER AND CORRELATION WITH EXISTING FLIGHT VIBRATION MEASUREMENTS Final Report
R. SOPHER and W. J. TWOMEY Apr. 1990 186 p
(Contract NAS1-17499)
(NASA-CR-182031; NAS 1.26:182031) Avail: NTIS HC A09/MF A01 CSCL 20/11

NASA-Langley is sponsoring a rotorcraft structural dynamics program with the objective to establish in the U.S. a superior capability to utilize finite element analysis models for calculations to support industrial design of helicopter airframe structures. In the initial phase of the program, teams from the major U.S. manufacturers of helicopter airframes will apply extant finite element analysis methods to calculate loads and vibrations of helicopter airframes, and perform correlations between analysis and measurements. The aforementioned rotorcraft structural dynamics program was given the acronym DAMVIBS (Design Analysis Method for Vibrations). Sikorsky's RDYNE Rotorcraft Dynamics Analysis used for the correlation study, the specifics of the application of RDYNE to the AH-1G, and comparisons of the predictions of the method with flight data for loads and vibrations on the AH-1G are described. RDYNE was able to predict trends of variations of loads and vibrations with airspeed, but in some instances magnitudes differed from measured results by factors of two or three to one. Sensitivities were studied of predictions to rotor inflow modeling, effects of torsional modes, number of blade bending modes, fuselage structural damping, and hub modal content. Author

N90-26166# Wichita State Univ., KS. Inst. for Aviation Research.
MECHANICAL PAINT REMOVAL TECHNIQUES FOR AIRCRAFT STRUCTURES
JOE P. AMRO and JORGE E. TALIA May 1990 20 p Presented at the 1990 AIAA/FAA Joint Symposium on General Aviation Systems
(NIAR-90-12) Avail: NTIS HC A03/MF A01

Paint removal by mechanical means, i.e., blasting, from aluminum structural aeronautical materials (2024-T3) was examined alone with the changes on the surface morphology introduced by the paint removal process. Three types of plastic particles were used in this research: Polyextra, Polyplus, and Type III. Scanning electron microscopy has shown that a potentially damaging surface morphology is formed on the surface of the structural material. Multiple microcracks or fissures generated by the stripping could reduce the life and/or change the engineering properties of the material. It was also found that aluminum material stripped using plastic media particles has a very rough surface that may affect the aerodynamic flow of an airplane. The number of microcracks and degree of surface roughness vary with the particle impact angle and velocity. To minimize or eliminate the damage done to the surface during the plastic particle stripping, it was necessary to change the blasting media to softer and smaller particles. Commercial wheat flour was selected for this purpose. With the substitution of these natural particles, the scanning electron microscopy observations of the stripped surface revealed no potential damage (microcracks or fissures) on the structural material, and the surface roughness was also reduced. Author

N90-26173# European Space Agency, Paris (France).
MATERIALS AND STRUCTURES FOR 2000 AND BEYOND: AN ATTEMPTED FORECAST BY THE DLR MATERIALS AND STRUCTURES DEPARTMENT
CARL-JOCHEN WINTER, MARTIN MAILAENDER, HEINRICH BERGMANN, HANS FOERSCHING, WOLFGANG BUNK, GERHARD GRUENINGER, and BERNDT FEUERBACHER May 1990 85 p Transl. into ENGLISH of Werkstoffe und Bauweisen fuer 2000 und Danach: Ein Versuch des DLR-Forschungsbereichs Werkstoffe und Bauweisen (Stuttgart, Fed. Republic of Germany, DFVLR), Feb. 1989 p 1-82 Original language document was announced as N89-25358 Previously announced as N90-18609 Revised
(ESA-TT-1154-REV; DFVLR-MITT-89-02-REV; ETN-90-97357) Avail: NTIS HC A05/MF A01; original German version available from DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne 90, Fed. Republic of Germany, 20.50 DM

The following forecasts were attempted on 21 to 22 Oct. 1988: to estimate what challenges the next 15 years might bring, and what would be the consequences for the direction and methodology of work, and for the organization of the institutes and of the research department. Building on the basis of the current position and of the discussions, the views of the five institutes, namely those for aeroelasticity, advanced design and manufacturing technology, space simulation, structural mechanics and materials research, on the future, are presented. A summary drawn up, and derived action guidelines, are given. ESA

N90-26210# Federal Aviation Administration, Atlantic City, NJ.
EQUIPMENT FEASIBILITY STUDY: VERY HIGH FREQUENCY COMMUNICATION EQUIPMENT (136-137 MEGAHERTZ)
JAMES AVILES, ED LIND, and LARRY MCMILLEN Jun. 1990 19 p
(DOT/FAA/CT-TN89/72) Avail: NTIS HC A03/MF A01

The feasibility of utilizing existing ground and airborne very high frequency (VHF) voice communication equipment for operation in the frequency range of 136 to 137 megahertz (MHz) was investigated. Existing general aviation databases were utilized and avionic transceiver manufactures consulted in an effort to estimate the numbers and capabilities of existing VHF communication transceivers to operate or be modified to operate up to 137 MHz. Information gathered for a sample of VHF communication transceivers manufactured over a certain time period was statistically projected to the entire general aviation population. Results indicate that: (1) Sixty-eight percent of the actual VHF communication transceivers will not cover the new band 136 to 137 MHz; and (2) Thirty-two percent of the actual VHF communication transceivers will cover the new band 136 to 137 MHz. Author

N90-26238# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
MOBILE SATELLITE COMMUNICATIONS FOR CIVIL AVIATION
T. H. M. HAGENBERG 3 Nov. 1988 25 p Presented at Symposium on Future Navigation, Communication, and Surveillance Systems, Schiphol, Netherlands, 1 Dec. 1988
(NLR-MP-88066-U; ETN-90-97192) Avail: NTIS HC A03/MF A01

Both voice and data communication of high quality without the line-of-sight propagation restriction or poor reliability are needed. In order to overcome the present limitations, the application of satellite communication is considered. A satellite communication system architecture will be standardized in the near future. The foreseen satellite communication architecture for civil aviation is discussed. ESA

N90-26268# Wichita State Univ., KS. Inst. for Aviation Research.
NUMERICAL ANALYSIS OF THREE-DIMENSIONAL PARTICLE-LADEN FLOW EQUATIONS PhD. Thesis
HOA V. CAO Feb. 1990 180 p
(IAR-90-2) Avail: NTIS HC A09/MF A01

A general numerical method for solving the full 3-D dusty gas viscous flow equations was developed. The dusty gas equations are numerically integrated forward in time by using the time-dependent MacCormack explicit predictor-corrector scheme. The numerical method was validated by computing the pure gas flowfield around a sphere at supersonic flow conditions and comparing these with existing experimental data and other numerical method solutions. Very good agreement is obtained. Two-phase flow results were calculated for a sphere for various combinations of freestream Mach numbers of 1.5 and 3, freestream loading ratios of 0.2 and 0.5, and particle radius of 1, 2, and 5 microns. In addition, flow solutions for a 3-D blunt body at angles of attack of 0, 5, and 10 degrees were also computed with a freestream Mach number of 1.5, a freestream loading ratios of

0.5 and a particle radius of 2 microns. Based on the present results, the following trends were identified: (1) the shock standoff distance is found to decrease and the stagnation properties are found to increase with increasing freestream loading ration and with decreasing particle radius; (2) the gas phase flowfield properties are only slightly different from that of a pure gas flowfield for a flow with a particle radius of 5 microns; and (3) the differences between pure gas and gas-particle flow results decrease with increasing freestream Mach number. Author

N90-26280# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
REPORT OF THE FLUID DYNAMICS PANEL WORKING GROUP 10 ON CALCULATION OF 3D SEPARATE TURBULENT FLOWS IN BOUNDARY LAYER LIMIT
May 1990 145 p
(AGARD-AR-255; ISBN-92-835-0560-3) Copyright Avail: NTIS HC A07/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The results of a study conducted by Working Group 10 of the AGARD Fluid Dynamics Panel to investigate the limits of boundary layer methods, both the integral and field type formulations, for calculating three-dimensional turbulent separated flow are presented. Test cases used to assess the boundary layer calculations included the DFLVR prolate spheroid at angle of attack and the NASA-Ames Wing C. Comparisons between boundary layer calculations and experimental data are presented for these test cases along with observations, conclusions, and recommendations. Author

N90-26281*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.
ANALYSIS AND MITIGATION OF NUMERICAL DISSIPATION IN INVISCID AND VISCID COMPUTATION OF VORTEX-DOMINATED FLOWS Final Report, Feb. - Nov. 1988
OSAMA A. KANDIL Aug. 1990 55 p
(Contract NAG1-846)
(NASA-CR-186887; NAS 1.26:186887) Avail: NTIS HC A04/MF A01 CSCL 20/4

The conservative unsteady Euler equations for the flow relative motion in the moving frame of reference are used to solve for the steady and unsteady flows around sharp-edged delta wings. The resulting equations are solved by using an implicit approximately-factored finite volume scheme. Implicit second-order and explicit second- and fourth-order dissipations are added to the scheme. The boundary conditions are explicitly satisfied. The grid is generated by locally using a modified Joukowski transformation in cross flow planes at the grid chord stations. The computational applications cover a steady flow around a delta wing whose results serve as the initial conditions for the unsteady flow around a pitching delta wing about a large angle of attack. The steady results are compared with the experimental data and the periodic solution is achieved within the third cycle of oscillation. Author

N90-26285# National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.
DEVELOPMENT OF A SYSTEM FOR THE NUMERICAL SIMULATION OF EULER FLOWS, WITH RESULTS OF PRELIMINARY 3-D PROPELLER-SLIPSTREAM/EXHAUST-JET CALCULATIONS Progress Report
J. W. BOERSTOEL 7 Jan. 1988 64 p Sponsored in cooperation with Aeritalia S.p.A., Naples, Italy and Fokker BV
(Contract NIVR-01604N)
(NLR-TR-88008-U; ETN-90-97183) Avail: NTIS HC A04/MF A01

The current status of a computer program system for the numerical simulation of Euler flows is presented. Preliminary test calculation results are shown. They concern the three-dimensional flow around a wing-nacelle-propeller-outlet configuration. The system is constructed to execute four major tasks: block decomposition of the flow domain around given, possibly complex, three-dimensional aerodynamic surfaces; grid generation on the blocked flow domain; Euler-flow simulation on the blocked grid; and graphical visualization of the computed flow on the blocked grid, and postprocessing. The system consists of about 20 codes interfaced by files. Most of the required tasks can be executed. The geometry of complex aerodynamic surfaces in three-dimensional space can be handled. The validation test showed that the system must be improved to increase the speed of the grid generation process. ESA

N90-26290# National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.
INFORMATICS ASPECTS OF LARGE FLOW CALCULATIONS ON THE SX-2 SUPERCOMPUTER
A. KASSIES 1 Jun. 1988 18 p In DUTCH; ENGLISH summary Presented at the NLR-WGS Symposium on Rekenen OP DE SX-2, 3 Jun. 1988 Sponsored by Netherlands Agency for Aerospace Engineering
(NLR-MP-88037-U; ETN-90-97187) Avail: NTIS HC A03/MF A01

The three-dimensional multiblock Euler code for arbitrary configurations, developed with a view to computer aided flow calculations for aircraft design, is described from an informatics point of view. A typical three-dimensional Euler calculations on a computational grid with 10 to the 6th power points takes about 10 to the 12th power floating point operations. The SX-2 supercomputer can complete this calculations in two hours, faster than other supercomputers. Furthermore the SX-2 has a very good FORTRAN compiler, but the operating system imposes that each file be allocated beforehand. The large extended memory allows three-dimensional Euler calculations on still finer grids as well as three-dimensional Navier-Stokes calculations. ESA

N90-26334*# Army Aviation Systems Command, Cleveland, OH.
EFFICIENCY STUDY COMPARING TWO HELICOPTER PLANETARY REDUCTION STAGES
TIMOTHY L. KRANTZ and ROBERT F. HANDSCHUH Jul. 1990 11 p Presented at the 26th Joint Propulsion Conference, Orlando, FL, 16-18 Jul. 1990; sponsored in part by AIAA, SAE, ASME, and ASEE
(Contract DA PROJ. 1L1-62211-A-47-A)
(NASA-TM-103106; E-5405; NAS 1.15:103106; AVSCOM-TM-90-C-005) Avail: NTIS HC A03/MF A01 CSCL 13/9

A study was conducted to compare the efficiency of two helicopter transmission planetary reduction stages. Experimental measurements and analytical predictions were made. The analysis predicted and experiments verified that one planetary stage was a more efficient design due to the type of planet bearing used in the stage. The effects of torque, speed, lubricant type, and lubricant temperature on planetary efficiency are discussed. Author

N90-26335# National Aerospace Lab., Tokyo (Japan). Aeroengine Div.
RESEARCH AND DEVELOPMENT OF ADVANCED GAS TURBINE
May 1989 74 p In JAPANESE; ENGLISH summary
(DE90-503377; NAL-TR-1023) Avail: NTIS (US Sales Only) HC A04/MF A01

The purposes of this research and development are as follows: to establish the technologies for a gas turbine with high efficiency and low emissions through the research and development of appropriate technology and heightening a turbine inlet temperature; to investigate the comprehensive energy supply systems such as district cooling and heating, a combined-cycle power generation system using the newly developed gas turbine; thus, to improve an overall thermal efficiency drastically. As a first stage of the study, a pilot plant of the high efficiency gas turbine was completed in order to realize the combined-cycle power plant with the overall thermal efficiency of 55 percent which is a final target, then demonstration operation of the plant was conducted. A waste heat boiler and a steam turbine which were integrated into the plant were simulated by a computer, and estimate calculations were carried out using a calculated value from the gas turbine by on-line. In the next stage, high temperature and high pressure

components such as a turbine and a combustor were designed and were fabricated by way of trial, then efficiency, durability and reliability of the components were verified through a high temperature and high speed turbine test equipment. DOE

N90-26345# Wichita State Univ., KS. Inst. for Aviation Research.
NEURAL NETWORKS FOR DETECTING DEFECTS IN AIRCRAFT STRUCTURES
BEHNAM BAHR and TARABISHY M. NABEEL Apr. 1990 14 p
(IAR-90-4) Avail: NTIS HC A03/MF A01

There are various nondestructive testing (NDT) inspection methods, such as vision, eddy current, and ultrasonic used for crack or corrosion detection of the skin or the structures of aircraft around rivets and fasteners. These methods require a skilled technician to identify the existence of the cracks. Despite the training that a technician goes through, human error is identified to be one of the major contributing factors to problems in the determination of the safety of aircraft. There has been some effort to develop expert systems that can be used by technicians. However, there is currently no expert system developed that can learn and improve its capability as it encounters new situations. The neural network and its possibility for aiding the technician in detecting defects is reviewed. Author

N90-26346# Wichita State Univ., KS. National Inst. for Aviation Research.
ROBOTIC-AIDED SYSTEM FOR INSPECTION OF AGING AIRCRAFT
BEHNAM BAHR and SAMI MAARI May 1990 13 p
(NIAR-90-9) Avail: NTIS HC A03/MF A01

There have been numerous catastrophic failures of in service aircraft due to cracks, corrosion, and human errors. Unfortunately, experts involved with this problem frequently reach different conclusions about the cause of the failure. But, in general they all agree that the reduction of human error is needed in inspection and maintenance of the aircraft; particularly aging aircraft which have been in service more than 15 to 19 years. Therefore, the objective of this work is to illustrate how a robotic system can be used for inspection aircraft. A new mobile robot concept for inspection of aircraft is presented. This approach will be especially useful for areas that are on the aircraft fuselage and not within easy reach. The robot can be programmed to follow a specified path while inspecting the structure. Vision and other inspection systems will be used to record the surface condition of the aircraft. The results of inspection regardless of technique (vision, eddy current, etc.), can be transmitted to the technician or an expert system for detection of cracks with/without human involvement. By using several robots simultaneously, the inspection time can be reduced with more consistent results. Author

N90-26348# Rolls-Royce Ltd., Derby (England).
NDT IN AEROSPACE: THE NEXT DECADE (1990'S)
R. G. TAYLOR 16 Aug. 1989 7 p Presented at the British Inst. Meeting, Minneapolis, MN, 16 Aug. 1989
(PNR90628; ETN-90-97139) Copyright Avail: NTIS HC A02/MF A01

Significant changes taking place in the aerospace industry, particularly in the area of aeroengine manufacture, which will have a considerable impact on the future role of nondestructive testing (NDT), are explained. The role of integrated inspection is discussed. Emphasis is on the manufacturing community rather than in-service NDT. The main changes are product life and reliability, materials development, and manufacturing strategy. ESA

N90-26349# Rolls-Royce Ltd., Derby (England).
THE ROLE OF NDI IN THE CERTIFICATION OF TURBINE ENGINE COMPONENTS
R. G. TAYLOR, SHARON I. VUKELICH, and THOMAS D. COOPER (Wright Research Development Center, Wright-Patterson AFB, OH.) 3 Oct. 1989 6 p Presented at the AGARD Specialists Meeting, 3-5 Oct. 1989
(PNR90629; ETN-90-97140) Copyright Avail: NTIS HC A02/MF A01

The historical reasons for the different approaches developed by the United Kingdom and U.S. in the use of NDI (non-destructive inspection) for the certification and lifting of aircraft gas turbine engine components are discussed. The current status of these activities, and future developments which may have the effect of minimizing the differences which exist, are reviewed. ESA

N90-26355*# General Electric Co., Cincinnati, OH. Aircraft Engine Business Group.
ELEVATED TEMPERATURE CRACK GROWTH Final Report
K. S. KIM, R. H. VANSTONE, S. N. MALIK, and J. H. LAFLEN Nov. 1988 293 p
(Contract NAS3-23940)
(NASA-CR-182247; NAS 1.26:182247; R89AEB-325) Avail: NTIS HC A13/MF A02 CSCL 20/11

A study was performed to examine the applicability of path-independent (P-I) integrals to crack growth problems in hot section components of gas turbine aircraft engines. Alloy 718 was used and the experimental parameters included combined temperature and strain cycling, thermal gradients, elastic-plastic strain levels, and mean strains. A literature review was conducted of proposed P-I integrals, and those capable of analyzing hot section component problems were selected and programmed into the postprocessor of a finite element code. Detailed elastic-plastic finite element analyses were conducted to simulate crack growth and crack closure of the test specimen, and to evaluate the P-I integrals. It was shown that the selected P-I integrals are very effective for predicting crack growth for isothermal conditions. Author

N90-26365# Central Research Inst. of Electric Power Industry, Tokyo (Japan). Energy and Environment Lab.
DEVELOPMENT OF CREEP-FATIGUE DAMAGE DETECTION METHOD OF ROTOR STEEL BY ULTRASONIC WAVE MEASUREMENT
MASAAKI MATSUBARA, AKIHITO NITTA, SHINSUKE SAKAI, and HIROYUKI OKAMURA May 1989 60 p In JAPANESE; ENGLISH summary
(DE90-503792; CRIE-T-88078) Avail: NTIS (US Sales Only) HC A04/MF A01

Nondestruction test for steam turbine rotor steel was studied in reference to the evaluation study for remainder in life of the aged thermal power generation equipment. According to the existing research, Fourier transform spectrum analysis can be done, and ultrasonic parameter can be accurately evaluated. And attenuation constant is considered to be effective to detect creep-fatigue damage. The accurate measurement for ultrasonic parameter can be realized by this method which was adopted in the study, as the position of probe is precisely controlled by personal computer. Damage distribution and crack initiation can be detected by this method more accurately than the conventional hardness method. Though the detection of local damage is important problem, application of envelope method and spectral method were considered to be effective among attenuation constant evaluation method. About the creep-fatigue damage detection method of rotor steel by ultrasonic wave, effectiveness of this method could be verified by specimen experiment by means of adjustment and establishment of basic technology. DOE

N90-26369# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
INVESTIGATION OF CRACK-CLOSURE PREDICTION MODELS FOR FATIGUE IN ALUMINIUM ALLOY SHEET UNDER FLIGHT-SIMULATION LOADING
UTAMA HERAWAN PADMADINATA Mar. 1990 361 p Sponsored by Agency for the Assessment and Application of Technology, Jakarta, Indonesia
(LR-619; ETN-90-97181) Avail: NTIS HC A16/MF A02

The need for crack growth prediction methods for use in the aircraft industry is addressed. Relevant aspects of fatigue

macrocrack growth are covered. Characteristics of simulation load histories, restricted to load spectra for aircraft wings, are discussed. The crack closure methods, PREFFAS, ONERA, and CORPUS are considered and results of flight simulation fatigue tests were collected to check the reliability of the models. The analysis of the three models showed that the effect of severe downwards loads is a weak point for all three models. The accuracy obtained with the CORPUS model appeared to be quite acceptable for practical applications. Points for further study revealed by the investigation are summarized. ESA

N90-26373*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
STRUCTURAL DYNAMICS BRANCH RESEARCH AND ACCOMPLISHMENTS Report, FY 1989
Jul. 1990 51 p
(NASA-TM-102488; E-5279; NAS 1.15:102488) Avail: NTIS HC A04/MF A01 CSCL 20/11

Summaries are presented of fiscal year 1989 research highlights from the Structural Dynamics Branch at NASA Lewis Research Center. Highlights from the branch's major work areas include aeroelasticity, vibration control, dynamic systems, and computation structural methods. A listing of the fiscal year 1989 branch publications is given. Author

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GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A90-44545#
CLOUD FEATURES SUGGESTING LOW LEVEL WIND SHEAR AND TURBULENCE
HIDEKI ITOH, TOSHIROH YOGAI, and TAKAO IMAIZUMI Meteorological Satellite Center, Technical Note (ISSN 0388-9653), no. 19, Nov. 1989, p. 1-25. In Japanese, with abstract in English.

Geostationary Meteorological Satellite (GMS) images are studied in order to find out whether ow-level (lower than 2000 ft) wind shear (LLWS) and turbulence are accompanied by characteristic cloud features. The investigation shows that moderate to severe LLWS and turbulence are accompanied by some characteristic cloud features, such as convective cloud lines, southern edges of major cloud systems of depression, wave clouds, cu cloud lines in cold air advection, and small cloud vortices. Some characteristic cloud features only appear near specific airports. It is suggested that GMS imagery is helpful in detecting LLWS and turbulence. Author

A90-45422* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TECHNOLOGY ISSUES FOR HIGH-SPEED CIVIL TRANSPORTS
SAMUEL M. DOLLYHIGH (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 11 p. refs
(SAE PAPER 892201) Copyright

Current efforts to prepare the technology for a new generation of high-speed civil transports are focused primarily on environmental issues. This paper reports on studies to provide: (1) acceptable engine emissions; (2) reduced airport/community noise; and (3) sonic-boom minimization. Attention is also given to technologies that allow a lighter, more efficient vehicle and to other high-payoff technologies, such as supersonic laminar flow; these have the potential for yielding not only better mission performance but also enhanced environmental compatibility for these new vehicles. The technology issues are reviewed in terms of the technologies themselves and their impact on the equally crucial need for economic success. Author

A90-45469
STAGES ARE FOR THEATERS - DECIBELS ARE FOR AIRPLANE NOISE MEASUREMENTS
STANLEY J. GREEN (General Aviation Manufacturers Association, Inc., Washington, DC) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 10 p.
(SAE PAPER 892293) Copyright

Some local government agencies and airport operators are considering using FAA's aircraft noise certification rules to differentiate acceptable from unacceptable airplanes in an attempt to achieve a reduction in noise from airplane operations. This paper demonstrates why FAA's 'stage' groupings of airplanes, while necessary and practical for airplane noise certification, is inappropriate for use as an operational means to reduce noise in the vicinity of a noise impacted airport. Author

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A90-42524
MONITORING AND MAINTENANCE OF AUTOMATIC CONTROL SYSTEMS IN AVIATION [INZHENERNO-TEKHNICHESKOE OBESPECHENIE AVTOMATIZIROVANNYKH SISTEM UPRAVLENIIA V AVIATSII]
MAKSIM V. SAVENKOV, RAFAEL' A. ZAKIROV, and ALEKSEI I. ZADOROZHNYI Moscow, Izdatel'stvo Mashinostroenie, 1989, 272 p. In Russian. refs
Copyright

The theory of the monitoring and maintenance of automatic control systems in aviation is presented, and recommendations are made on the planning of monitoring and maintenance operations. Particular attention is given to the training of personnel responsible for the servicing of automatic control systems. Examples of monitoring and maintenance experience are given. B.J.

A90-44644
MULTIPLE SENSOR DATA ASSOCIATION AND FUSION IN AEROSPACE APPLICATIONS
S. S. BLACKMAN (Hughes Aircraft Co., Electro-Optical and Data Systems Group, El Segundo, CA) and T. J. BROIDA (Hughes Aircraft Co., Radar Systems Group, Los Angeles, CA) Journal of Robotic Systems (ISSN 0741-2223), vol. 7, June 1990, p. 445-485. refs
Copyright

Issues and methods encountered in the use of multiple sensors for surveillance and tracking problems that arise in aerospace and defense are presented. The functions of data association (the labeling of data from different sensors, at different times, that correspond to the same object or feature) and data fusion (the combining of data efficiently with minimal loss of information) are discussed for both collocated and distributed sensing systems. It is noted that these functions are central to any multiple sensor fusion application. Use of multiple hypothesis tracking (MHT) for data association is analyzed and it is suggested that the use of MHT may offer a way of dealing with data association ambiguities. Finally, the problem of allocating sensor resources is discussed and a general methodology for evaluating multiple sensor tracking performance is given. L.K.S.

A90-44832#
PARAMETER SENSITIVITY ANALYSIS OF ONE KIND OF FLIGHT PATH RECONSTRUCTION ESTIMATOR
JIAN LUO, JIANPING LI, and WEI ZHANG (Northwestern Polytechnical University, Xian, People's Republic of China) Northwestern Polytechnical University, Journal (ISSN 1000-2758), vol. 8, July 1990, p. 311-318. In Chinese, with abstract in English. refs

This paper explores the parameter sensitivity of the estimator of the general Kalman filter for nonlinear and time-varying flight path reconstruction. The influence of uncertainties in the initial state vector (ISV), the initial filtering error covariance matrix P(0), the measurement covariance matrix R, and the input covariance matrix Q on the estimated output of the filter is examined. The results show that ISV has the strongest influence on the estimated output, followed by P(0) and R, and that the influence of Q is rather weak. C.D.

A90-44855#
COMPRESSIBLE FLOW ALGORITHMS ON STRUCTURED/UNSTRUCTURED GRIDS
ROBERT W. WALTERS (Virginia Polytechnic Institute and State University, Blacksburg) International Conference on Computing Methods in Applied Sciences and Engineering, 9th, Paris, France, Jan. 29-Feb. 2, 1990, Paper. 21 p. refs

Various techniques for implementing upwind flux-split schemes for the Euler and Navier-Stokes equations on unstructured meshes are reviewed. The development of a space-marching technique on hybrid structured/unstructured meshes is presented. In addition, time integration algorithms on unstructured grids with an emphasis on convergence acceleration to the steady state are compared. An m-stage Jameson-style explicit Runge-Kutta scheme is used as a baseline comparison. Implicit schemes discussed include a highly vectorizable skyline sparse matrix solver, hybrid explicit/implicit time advancement schemes, and various relaxation strategies. Mesh adaptation techniques are also discussed. Results in both two and three dimensions are presented, including (1) a supersonic inlet calculation with complex wave interactions and (2) a space-marching inviscid simulation on an unstructured mesh about a high-speed reconnaissance aircraft. Author

A90-45289
COMPUTER AIDED ANALYSIS OF GAS TURBINE CYCLES
K. W. LINDLER (U.S. Naval Academy, Annapolis, MD) IN: Computers in engineering 1989; Proceedings of the ASME International Computers in Engineering Conference and Exposition, Anaheim, CA, July 30-Aug. 3, 1989. Volume 2. New York, American Society of Mechanical Engineers, 1989, p. 191-196. Research supported by the U.S. Naval Academy.
Copyright

An educational computer program called Brayton is described which can be used to perform various parametric studies of thermodynamic cycles describing the performance of gas turbines. Students have been able to master the program in 10-20 minutes and complete an entire assignemt using the program in one to two hours. Student reaction to the program is reported along with typical laboratory exercise results. C.D.

A90-45290
TURBOFAN ENGINE ANALYSIS AND OPTIMIZATION USING SPREADSHEETS
K. C. WESTON (Tulsa, University, OK) IN: Computers in engineering 1989; Proceedings of the ASME International Computers in Engineering Conference and Exposition, Anaheim, CA, July 30-Aug. 3, 1989. Volume 2. New York, American Society of Mechanical Engineers, 1989, p. 197-202. refs
Copyright

This papear is concerned with the rapid and convenient analysis and optimization of turbofans and other jet engines for purposes of preliminary design and for instruction in engineering. Spreadsheets have been developed in connection with a senior elective course in gas turbines. These spreadsheets allow rapid analysis of single and multiple cases. It is clear that the effort involved in developing the spreadsheet, quantitative results, and plots of performance is significantly less than if a high-level computer language had been used. A spreadsheet macro tool developed to simplify multicase documentation and the entry of interactive input parameters is also presented and demonstrated. Author

A90-45373
A FRAMEWORK FOR THE OPTIMAL DESIGN OF INSTRUCTOR/OPERATOR STATIONS IN FLIGHT SIMULATORS
R. RAMESH (New York, State University, Buffalo) and CHEICKNA SYLLA (New Jersey Institute of Technology, Newark) IEEE Transactions on Systems, Man, and Cybernetics (ISSN 0018-9472), vol. 20, May-June 1990, p. 571-581. refs
Copyright

The flight training process is conceptualized using a systems approach, and a framework for developing cost-effective training programs is presented. Using this approach, an expert decision support system for the optimal design of instructor/operator stations (IOSs) in flight simulators was developed. The system enables a designer to evaluate various IOS design configurations and choose a cost-effective configuration for implementation. The system encapsulates the knowledge on the design problem, its parameters, and the associated data assessed from a group of experts in flight simulation. The system was implemented on an IBM PC/AT and field tested with a group of design engineers. Their overall response to this system has been very favorable. Covered are the design approach, a taxonomy of the design parameters, the optimization model, and the system characteristics. Avenues of future investigation identified from this study are noted. I.E.

N90-25078# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.). Unternehmensgruppe Hubschrauber und Flugzeuge.
DEVELOPMENT AND APPLICATION OF AN OPTIMIZATION PROCEDURE FOR SPACE AND AIRCRAFT STRUCTURES
GUENTER KNEPPE, WOLFGANG HARTZHEIM, and GEORG ZIMMERMANN *In its* Research and Development: Technical and Scientific Publications 1989 p 23-28 1989 Presented at GAMM-Seminar on Discretization Methods and Structural Optimization, 1989
(MBB-FW-522/S/PUB-383) Avail: NTIS HC A15/MF A02

An optimization procedure is presented, that allows the dimensioning of homogeneous isotropic, orthotropic or anisotropic structures and fiber reinforced materials with respect to weight, static, dynamic, aeroelastic and manufacturing requirements. Design variables were sizing and geometric dimensions. The structural and sensitivity analysis was based on the finite element method. Some examples, such as frequency and heat flux optimization of a satellite structure, stress optimization of a wheel, and geometry optimization of an aluminum alloy used for the cabin floor of an aeroplane show the good adaptability of the model for the large scale problems with a high number of design variables and constraints. An integration into the CAE (Computer Aided Engineering) environment by the use of standard interfaces is *important for practical applications.* ESA

N90-25515*# Aerospace Medical Research Labs., Wright-Patterson AFB, OH.
CREW CHIEF: A COMPUTER GRAPHICS SIMULATION OF AN AIRCRAFT MAINTENANCE TECHNICIAN
NILSS M. AUME *In* NASA, Lyndon B. Johnson Space Center, Third Annual Workshop on Space Operations Automation and Robotics (SOAR 1989) p 139-141 Mar. 1990
Avail: NTIS HC A99/MF A04 CSCL 09/2

Approximately 35 percent of the lifetime cost of a military system is spent for maintenance. Excessive repair time is caused by not considering maintenance during design. Problems are usually discovered only after a mock-up has been constructed, when it is too late to make changes. CREW CHIEF will reduce the incidence of such problems by catching design defects in the early design

stages. CREW CHIEF is a computer graphic human factors evaluation system interfaced to commercial computer aided design (CAD) systems. It creates a three dimensional man model, either male or female, large or small, with various types of clothing and in several postures. It can perform analyses for physical accessibility, strength capability with tools, visual access, and strength capability for manual materials handling. The designer would produce a drawing on his CAD system and introduce CREW CHIEF in it. CREW CHIEF's analyses would then indicate places where problems could be foreseen and corrected before the design is frozen. Author

N90-25516*# Aerospace Medical Research Labs., Wright-Patterson AFB, OH.
MODELING STRENGTH DATA FOR CREW CHIEF
JOE W. MCDANIEL *In* NASA, Lyndon B. Johnson Space Center, Third Annual Workshop on Space Operations Automation and Robotics (SOAR 1989) p 143-148 Mar. 1990
Avail: NTIS HC A99/MF A04 CSCL 09/2

The Air Force has developed CREW CHIEF, a computer-aided design (CAD) tool for simulating and evaluating aircraft maintenance to determine if the required activities are feasible. CREW CHIEF gives the designer the ability to simulate maintenance activities with respect to reach, accessibility, strength, hand tool operation, and materials handling. While developing the CREW CHIEF, extensive research was performed to describe workers strength capabilities for using hand tools and manual handling of objects. More than 100,000 strength measures were collected and modeled for CREW CHIEF. These measures involved both male and female subjects in the 12 maintenance postures included in CREW CHIEF. The data collection and modeling effort are described. Author

N90-25568*# Air Force Human Resources Lab., Brooks AFB, TX. Manpower and Personnel Div.
SUCCESS IN TUTORING ELECTRONIC TROUBLESHOOTING
ELLEN M. PARKER *In* NASA, Lyndon B. Johnson Space Center, Third Annual Workshop on Space Operations Automation and Robotics (SOAR 1989) p 593-603 Mar. 1990
Avail: NTIS HC A99/MF A04 CSCL 09/2

Two years ago Dr. Sherrie Gott of the Air Force Human Resources Laboratory described an avionics troubleshooting tutor being developed under the Basic Job Skills Research Program. The tutor, known as Sherlock, is directed at teaching the diagnostic procedures necessary to investigate complex test equipment used to maintain F-15 fighter aircraft. Since Dr. Gott's presentation in 1987, the tutor has undergone field testing at two Air Force F-15 flying wings. The results of the field test showed that after an average of 20 hours on the tutor, the 16 airmen in the experimental group (who average 28 months of experience) showed significant performance gains when compared to a control group (having a mean experience level of 37 months) who continued participating in the existing on-the-job training program. Troubleshooting performance of the tutored group approached the level of proficiency of highly experienced airmen (averaging approximately 114 months of experience), and these performance gains were confirmed in delayed testing six months following the intervention. The tutor is currently undergoing a hardware and software conversion form a Xerox Lisp environment to a PC-based environment using an object-oriented programming language. Summarized here are the results of the successful field test. The focus is on: (1) the instructional features that contributed to Sherlock's success; and (2) the implementation of these features in the PC-based version of the avionics troubleshooting tutor. Author

N90-25580*# Stevens Inst. of Tech., Hoboken, NJ.
HARDWARE AND SOFTWARE RELIABILITY ESTIMATION USING SIMULATIONS Final Report
FREDERIC L. SWERN Jun. 1990 152 p
(Contract NAG1-587)
(NASA-CR-186637; NAS 1.26:186637) Avail: NTIS HC A08/MF A01 CSCL 09/2

The overall objective is to provide estimates of the system characteristics that are necessary to calculate the probability of system failure due to latency. It would be desirable to supply both a methodology for measuring latency, and an estimate of its effects in a typical avionics application. It is also desirable to measure the probability of failure of the software embedded in a flight critical piece of hardware using similar techniques to those used for measuring hardware latency. To achieve these objectives, simulations were constructed that were appropriate tor the type of system being tested (i.e., hardware or software). It was concluded that simulation is a viable means for validating both hardware and software and associating a reliability number with each. This is useful in determining the overall probability of system failure of an embedded processor unit, and improving both the code and the hardware where necessary to meet reliability requirements. The methodologies were proven using some simple programs and simple hardware models. Author

N90-25638*# Boeing Advanced Systems Co., Seattle, WA.
RELIABILITY MODEL GENERATOR SPECIFICATION Final Report
GERALD C. COHEN and CATHERINE MCCANN Mar. 1990 247 p
(Contract NAS1-18099)
(NASA-CR-182005; NAS 1.26:182005) Avail: NTIS HC A11/MF A02 CSCL 12/2

The Reliability Model Generator (RMG), a program which produces reliability models from block diagrams for ASSIST, the interface for the reliability evaluation tool SURE is described. An account is given of motivation for RMG and the implemented algorithms are discussed. The appendices contain the algorithms and two detailed traces of examples. Author

N90-26511*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
KNOWLEDGE-BASED SYSTEM FOR FLIGHT INFORMATION MANAGEMENT Thesis
WENDELL R. RICKS Jun. 1990 90 p
(NASA-TM-102685; NAS 1.15:102685) Avail: NTIS HC A05/MF A01 CSCL 09/2

The use of knowledge-based system (KBS) architectures to manage information on the primary flight display (PFD) of commercial aircraft is described. The PFD information management strategy used tailored the information on the PFD to the tasks the pilot performed. The KBS design and implementation of the task-tailored PFD information management application is described. The knowledge acquisition and subsequent system design of a flight-phase-detection KBS is also described. The flight-phase output of this KBS was used as input to the task-tailored PFD information management KBS. The implementation and integration of this KBS with existing aircraft systems and the other KBS is described. The flight tests are examined of both KBS's, collectively called the Task-Tailored Flight Information Manager (TTFIM), which verified their implementation and integration, and validated the software engineering advantages of the KBS approach in an operational environment. Author

N90-26515*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
A COMPUTER MODULE USED TO CALCULATE THE HORIZONTAL CONTROL SURFACE SIZE OF A CONCEPTUAL AIRCRAFT DESIGN
DORAL R. SANDLIN and STEPHEN MARK SWANSON Aug. 1990 122 p
(Contract NCC2-236)
(NASA-CR-186872; NAS 1.26:186872) Avail: NTIS HC A06/MF A01 CSCL 09/2

The creation of a computer module used to calculate the size of the horizontal control surfaces of a conceptual aircraft design is discussed. The control surface size is determined by first calculating the size needed to rotate the aircraft during takeoff, and, second, by determining if the calculated size is large enough to maintain stability of the aircraft throughout any specified mission. The tail size needed to rotate during takeoff is calculated from a

summation of forces about the main landing gear of the aircraft. The stability of the aircraft is determined from a summation of forces about the center of gravity during different phases of the aircraft's flight. Included in the horizontal control surface analysis are: downwash effects on an aft tail, upwash effects on a forward canard, and effects due to flight in close proximity to the ground. Comparisons of production aircraft with numerical models show good accuracy for control surface sizing. A modified canard design verified the accuracy of the module for canard configurations. Added to this stability and control module is a subroutine that determines one of the three design variables, for a stable vectored thrust aircraft. These include forward thrust nozzle position, aft thrust nozzle angle, and forward thrust split. Author

N90-26564*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
AN AUTOMATED CALIBRATION LABORATORY FOR FLIGHT RESEARCH INSTRUMENTATION: REQUIREMENTS AND A PROPOSED DESIGN APPROACH
NORA ONEILL-ROOD and RICHARD D. GLOVER May 1990 16 p Presented at the 36th ISA International Instrumentation Symposium, Denver, CO, 7-10 May 1990
(NASA-TM-101719; H-1594; NAS 1.15:101719) Avail: NTIS HC A03/MF A01 CSCL 09/2

NASA's Dryden Flight Research Facility (Ames-Dryden), operates a diverse fleet of research aircraft which are heavily instrumented to provide both real time data for in-flight monitoring and recorded data for postflight analysis. Ames-Dryden's existing automated calibration (AUTOCAL) laboratory is a computerized facility which tests aircraft sensors to certify accuracy for anticipated harsh flight environments. Recently, a major AUTOCAL lab upgrade was initiated; the goal of this modernization is to enhance productivity and improve configuration management for both software and test data. The new system will have multiple testing stations employing distributed processing linked by a local area network to a centralized database. The baseline requirements for the new AUTOCAL lab and the design approach being taken for its mechanization are described. Author

N90-26595*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
ON CENTRAL-DIFFERENCE AND UPWIND SCHEMES Final Report
R. C. SWANSON (National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.) and ELI TURKEL Jun. 1990 43 p Prepared in cooperation with Tel-Aviv Univ. (Israel) Submitted for publication
(Contract NAS1-18605)
(NASA-CR-182061; ICASE-90-44; NAS 1.26:182061) Avail: NTIS HC A03/MF A01 CSCL 12/1

A class of numerical dissipation models for central-difference schemes constructed with second- and fourth-difference terms is considered. The notion of matrix dissipation associated with upwind schemes is used to establish improved shock capturing capability for these models. In addition, conditions are given that guarantee that such dissipation models produce a Total Variation Diminishing (TVD) scheme. Appropriate switches for this type of model to ensure satisfaction of the TVD property are presented. Significant improvements in the accuracy of a central-difference scheme are demonstrated by computing both inviscid and viscous transonic airfoil flows. Author

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A90-42638
SOUND GENERATION BY A SUPERSONIC AEROFOIL CUTTING THROUGH A STEADY JET FLOW
Y. P. GUO (Saint John's College, Cambridge, England) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 216, July 1990, p. 193-212. refs
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This paper examines the sound generation process when a supersonic aerofoil cuts through a steady jet flow. It is shown that the principal sound is generated by the leading edge of the aerofoil when it interacts with the streaming jet. To the leading order in terms of the jet velocity, no trailing-edge sound is generated. This is not the result of the cancellation of a trailing-edge sound by that from vortex shedding through the imposition of the Kutta condition. Instead, the null acoustic radiation from the trailing edge is entirely because, to the leading order, there is no interaction between the trailing edge and the jet. The effect of the trailing edge is to diffract sound waves generated by the leading edge. It is shown that the diffracted field (as well as the incident field) is regular at the trailing edge and the issue of satisfying the Kutta condition does not arise during the diffraction process. Thus, there is no extra vortex shedding from the trailing edge owing to its interaction with the flow, apart from those resulting from the discontinuity across the aerofoil, generated by the flow-leading edge interaction. This is in sharp contrast to the case of subsonic aerofoils where the removal of the singularity in the diffracted field at the trailing edge through the imposition of the Kutta condition results in vortex shedding from the sharp edge and energy exchange between the sound field and the vortical wake. Author

A90-42874*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A NEW CLASS OF RANDOM PROCESSES WITH APPLICATION TO HELICOPTER NOISE
JAY C. HARDIN (NASA, Langley Research Center, Hampton, VA) and A. G. MIAMEE (Hampton University, VA) IN: Developments in mechanics. Volume 15 - Midwestern Mechanics Conference, 21st, Houghton, MI, Aug. 13-16, 1989, Proceedings. Houghton, MI, Michigan Technological University, 1989, p. 79-94. Previously announced in STAR as N89-26679. refs

The concept of dividing random processes into classes (e.g., stationary, locally stationary, periodically correlated, and harmonizable) has long been employed. A new class of random processes is introduced which includes many of these processes as well as other interesting processes which fall into none of the above classes. Such random processes are denoted as linearly correlated. This class is shown to include the familiar stationary and periodically correlated processes as well as many other, both harmonizable and non-harmonizable, nonstationary processes. When a process is linearly correlated for all t and harmonizable, its two-dimensional power spectral density S(x) (omega 1, omega 2) is shown to take a particularly simple form, being non-zero only on lines such that omega 1 to omega 2 = + or - r(k) where the r(k's) are (not necessarily equally spaced) roots of a characteristic function. The relationship of such processes to the class of stationary processes is examined. In addition, the application of such processes in the analysis of typical helicopter noise signals is described. Author

A90-43782
ACOUSTIC EMISSION AND SIGNAL ANALYSIS
A. K. RAO (Indian Institute of Science, Bangalore, India) Defence Science Journal (ISSN 0011-748X), vol. 40, Jan. 1990, p. 55-70.

Research supported by the Aeronautical Research and Development Board. refs
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A review is given of the acoustic emission (AE) phenomenon and its applications in NDE and geological rock mechanics. Typical instrumentation used in AE signal detection, data acquisition, processing, and analysis is discussed. The parameters used in AE signal analysis are outlined, and current methods of AE signal analysis procedures are discussed. A literature review is presented on the pattern classification of AE signals. A discussion then follows on the application of AE in aircraft component monitoring, with an experiment described which focuses on in-flight AE monitoring during fatigue crack growth in an aero engine mount. A pattern recognition approach is detailed for the classification of the experimental data. The approach subjects each of the data files to a cluster analysis by the threshold-k-means scheme. The technique is shown to classify the data successfully. S.A.V.

A90-45519
THE MDE METHOD FOR AIRCRAFT CABIN INTERIOR NOISE PREDICTION
P. H. DENKE (Douglas Aircraft Co., Long Beach, CA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 13 p. refs
(SAE PAPER 892372) Copyright

This paper describes a finite-element method, based on the matrix difference equation (MDE) method of Denke (1979), for predicting aircraft-cabin interior noise, using coupled structural-acoustic models to represent the fuselage structure and the air inside. In this method, the problem of modeling coupled structural-acoustic systems is solved by the FEM, employing displacements as the unknown variables. The method is shown to be efficient enough to be employed as a design tool. I.S.

N90-25553*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VISUALIZATION OF THREE DIMENSIONAL DATA
STEPHEN R. ELLIS, STEPHEN SMITH, and SELIM HACISALIHZADE *In* NASA, Lyndon B. Johnson Space Center, Third Annual Workshop on Space Operations Automation and Robotics (SOAR 1989) p 465-469 Mar. 1990
Avail: NTIS HC A99/MF A04 CSCL 20/6

The objective of research is to characterize patterns of errors observers make when relating the judged exocentric direction of a target presented on a perspective display to their egocentric sense of visual direction. This type of spatial task is commonly faced by operators of telerobotic systems when using a map-like display of their workspace to determine the visual location and orientation of objects seen by direct view. It is also essentially the same task as faced by an aircraft pilot using a cockpit perspective traffic display of his surrounding airspace to locate traffic out his windows. The results of the current study clearly show that the visual direction is a significantly biased metric of virtual space presented by flat panel perspective displays. Modeling and explanation of the causes of the observed biases will allow design of compensated perspective displays. Author

N90-26633*# General Electric Co., Cincinnati, OH. Advanced Technology Operations.
HIGH SPEED TURBOPROP AEROACOUSTIC STUDY (COUNTERROTATION). VOLUME 1: MODEL DEVELOPMENT Final Report
C. E. WHITFIELD, R. MANI, and P. R. GLIEBE Jul. 1990 121 p
(Contract NAS3-23721)
(NASA-CR-185241; NAS 1.26:185241) Avail: NTIS HC A06/MF A01 CSCL 20/1

The isolated counterrotating high speed turboprop noise prediction program was compared with model data taken in the GE Aircraft Engines Cell 41 anechoic facility, the Boeing Transonic Wind Tunnel, and in NASA-Lewis' 8x6 and 9x15 wind tunnels. The predictions show good agreement with measured data under both low and high speed simulated flight conditions. The installation effect model developed for single rotation, high speed turboprops was extended to include counterotation. The additional effect of mounting a pylon upstream of the forward rotor was included in the flow field modeling. A nontraditional mechanism concerning the acoustic radiation from a propeller at angle of attach was investigated. Predictions made using this approach show results that are in much closer agreement with measurement over a range of operating conditions than those obtained via traditional fluctuating force methods. The isolated rotors and installation effects models were combines into a single prediction program, results of which were compared with data taken during the flight test of the B727/UDF engine demonstrator aircraft. Satisfactory comparisons between prediction and measured data for the demonstrator airplane, together with the identification of a nontraditional radiation mechanism for propellers at angle of attack are achieved. Author

N90-26634*# *Duke Univ., Durham, NC. School of Engineering.*
ASYMPTOTIC MODAL ANALYSIS AND STATISTICAL ENERGY ANALYSIS Progress Report, 15 Oct. 1989 - 14 Apr. 1990
EARL H. DOWELL and LINDA F. PERETTI 1990 22 p Presented at the 118th Acoustical Society of America Meeting, Saint Louis, MO, 27 Nov. - 1 Dec. 1989
(Contract NAG1-709)
(NASA-CR-186732; NAS 1.26:186732) Avail: NTIS HC A03/MF A01 CSCL 20/1

The sound field of a structural-acoustic enclosure was subject to experimental analysis and theoretical description in order to develop an efficient and accurate method for predicting sound pressure levels in enclosures such as aircraft fuselages. Asymptotic Modal Analysis (AMA) is the method under investigation. AMA is derived from classical modal analysis (CMA) by considering the asymptotic limit of the sound pressure level as the number of acoustic and/or structural modes approaches infinity. Using AMA, results identical to those of Statistical Energy Analysis (SEA) were obtained for the spatially-averaged sound pressure levels in the interior. AMA is systematically derived from CMA and therefore the degree of generality of the end result can be adjusted through the choice of appropriate simplifying assumptions. For example, AMA can be used to obtain local sound pressure levels at particular points inside the enclosure, or to include the effects of varying the size and/or location of the sound source. AMA theoretical results were compared with CMA theory and also with experiment for the case where the structural-acoustic enclosure is a rectangular cavity with part of one wall flexible and vibrating, while the rest of the cavity is rigid. Author

N90-26635*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AEROACOUSTICS OF ADVANCED PROPELLERS
JOHN F. GROENEWEG 1990 21 p Presented at the 17th Congress of the International Council of Aeronautical Sciences, Stockholm, Sweden, 9-14 Sep. 1990; sponsored by AIAA
(NASA-TM-103137; E-5446; NAS 1.15:103137) Avail: NTIS HC A03/MF A01 CSCL 20/1

The aeroacoustics of advanced, high speed propellers (propfans) are reviewed from the perspective of NASA research conducted in support of the Advanced Turboprop Program. Aerodynamic and acoustic components of prediction methods for near and far field noise are summarized for both single and counterrotation propellers in uninstalled and configurations. Experimental results from tests at both takeoff/approach and cruise conditions are reviewed with emphasis on: (1) single and counterrotation model tests in the NASA Lewis 9 by 15 (low speed) and 8 by 6 (high speed) wind tunnels, and (2) full scale flight tests of a 9 ft (2.74 m) diameter single rotation wing mounted tractor and a 11.7 ft (3.57 m) diameter counterrotation aft mounted pusher propeller. Comparisons of model data projected to flight with full scale flight data show good agreement validating the scale model wind tunnel approach. Likewise, comparisons of measured and predicted noise level show excellent agreement for both single and counterrotation propellers. Progress in describing

angle of attack and installation effects is also summarized. Finally, the aeroacoustic issues associated with ducted propellers (very high bypass fans) are discussed. Author

N90-26637# Rolls-Royce Ltd., Derby (England).
BRINGING AIRCRAFT NOISE TESTING DOWN TO EARTH
M. J. T. SMITH 21 Apr. 1989 20 p Presented at the 1989 European Propulsion Forum on Modern Techniques and Development of Engine Component Testing: Bringing Aircraft Noise Testing Down to Earth, Bath, England, 19-21 Apr. 1989
(PNR90642; ETN-90-97146) Copyright Avail: NTIS HC A03/MF A01

Specifications and a description of the noise test facility at Hucknall (United Kingdom) are presented. The facility was constructed to allow a 35 KN (80,000 lb) thrust class engine to be tested and the structure capable of development to take 50 KN. The acoustic data collection system is described and its benefits outlined. Considerations to the local environment are outlined and the construction, experience and status are discussed. The concept of test bed rotatability improved the window of test opportunity three to fourfold and the use of digital techniques allows a full engine test of about 10 stabilized power conditions to be completed within one hour. Analysis is subsequently carried out overnight and real time data is available on line at the time of test. ESA

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

N90-25697# Wichita State Univ., KS. Inst. for Aviation Research.
PROGRAM PLAN: INTERNATIONAL AIRCRAFT OPERATOR DATA BASE Report, Jan. 1990
JOHN J. HUTCHINSON and FRANK MACHEERS Dec. 1989 14 p
(Contract DTFA03-89-C-00057)
(IAR-90-1; DOT/FAA/CT-89/34) Avail: NTIS HC A03/MF A01

This Program Plan describes studies and research which will result in a Master Requirements and Implementation Plan for the creation of an international data base of all operators of United States type-certificated aircraft. This Master Plan assesses the FAA's requirements concerning the availability, acquisition, and development of international aircraft operator data. Efforts involve identifying problem areas and information gaps, and recommending solutions or options. The Master Plan begins with a determination of the FAA's needs for aircraft operator data and concludes with recommendations of data base development. These are directed toward meeting the requirement to distribute airworthiness safety information to aircraft operators in a cost effective manner using an automated, menu driven, filing and retrieval system. Author

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GENERAL

A90-42828#
THE HISTORY OF AVIATION ENGINE DEVELOPMENT IN THE USSR AND THE 60TH ANNIVERSARY OF CIAM
V. A. SOSUNOV (Tsentral'nyi Nauchno-Issledovatel'skii Institut Aviatsionnogo Motorostroeniia, Moscow, USSR) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 18 p.
(AIAA PAPER 90-2761) Copyright

The development of aviation engines and its close association with the Central Institute of Aviation Motors (CIAM) in the USSR is reviewed. Attention is given to the development of aviation engines from the prewar period through the beginning of turbojet engine test experiments, along with the associated requirements for the rapid evolution of high-performance jet aircraft. The facilities for basic research and testing are described, and future plans are briefly characterized. R.E.P.

N90-25930# Federal Aviation Administration, Washington, DC.
THE FEDERAL AVIATION ADMINISTRATION PLAN FOR RESEARCH, ENGINEERING AND DEVELOPMENT. VOLUME 1: PROGRAM PLAN
Jan. 1989 155 p
(AD-A221263) Avail: NTIS HC A08/MF A01 CSCL 05/4

The publication of this RE and D Plan represents a new start in the revitalizaiton of the FAA's RE and D Program. A program was developed to work more closely with the aviation industry and to be responsive to the Aviation Safety Research Act of 1988. The plan also provides a balance between near- and long-term research activities to provide effective solutions to immediate problems and provide a base for the aviation system of the 21st century. Author

N90-25931# Federal Aviation Administration, Washington, DC.
THE FEDERAL AVIATION ADMINISTRATION PLAN FOR RESEARCH, ENGINEERING AND DEVELOPMENT. VOLUME 2: PROJECT DESCRIPTIONS
Jan. 1989 264 p
(AD-A221264) Avail: NTIS HC A12/MF A02 CSCL 05/4

The FAA RE and D plan addresses the present and future needs of the national aviation system through fulfillment of the FAA's major mission areas. Detailed descriptions are presented of the projects included in the RE and D Plan. For planning purposes, the time frame is broken into three windows, with 1989 to 1995 composing the near term, 1996 to 2005 the mid-term, and 2006 to 2015 the far term. The project plans described were organized into the following 13 technical areas: system studies; air traffic control; communications; navigation and landing; surveillance; aviation weather; satellite applications; airborne systems; airports; aircraft safety; aviation medicine; security; and human systems and operations. Author

N90-26788# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AGARD HIGHLIGHTS 90/1
Mar. 1990 57 p
Copyright Avail: NTIS HC A04/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Progress made in AGARD programs is reported. Topics addressed include: the Turkish defense industry; Turkish aviation and the aeronautical industry; structures and materials in the 90s; the collaborative role of AGARD in recent advances in rotorcraft system identification; and new defense research document policy. B.G.

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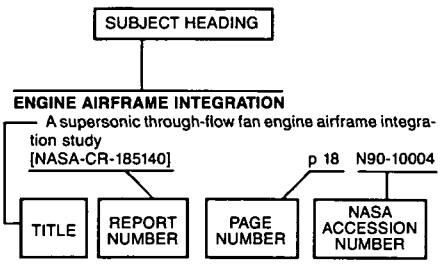

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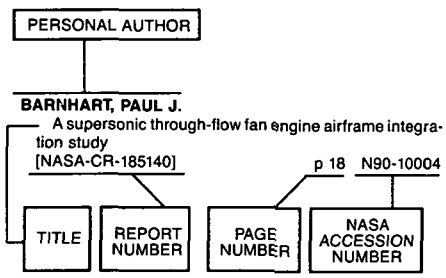

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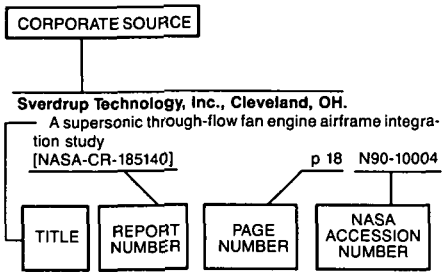

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[AD-A222582] p 762 N90-26020

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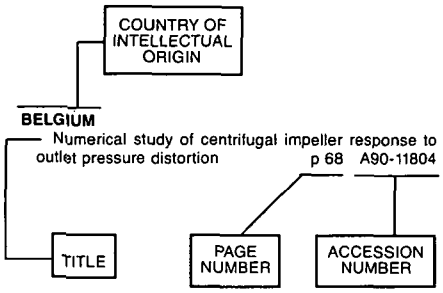

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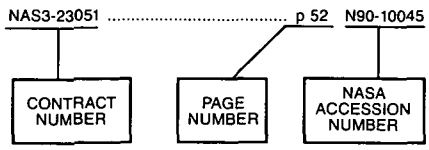

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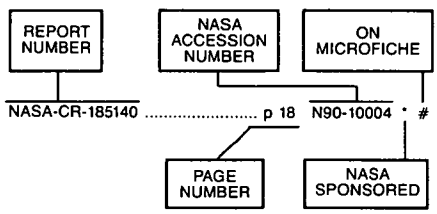

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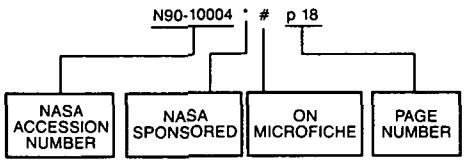

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